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VOLUME NO. 4

EXPLANATORY NOTES

FOR

DEPARTMENT OF AGRICULTURE

BUDGET ESTIMATES

FISCAL YEAR

1942

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BUREAU OF AGRICULTURAL CHEMISTRY AND ENGINEERING

(a) GENERAL ADMINISTRATIVE EXPENSES

Appropriation Act, 1941	$105,300
Transferred 1941, pursuant to Reorganization Plan No. IV, to "United States Mail and Messenger Service, Post Office Department (General Fund)"	- 100
Total available, 1941	105,200
Budget Estimate, 1942	105,200

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)
General administration and business service	$103,645	$105,200	$105,200
Unobligated balance	1,655	- -	- -
Total	105,300	105,200	105,200

WORK UNDER THIS APPROPRIATION

This appropriation provides for administrative supervision and direction of the work of the Bureau and to carry on the business activities necessary for the proper functioning of the organization as a whole, including personnel, budget, bookkeeping, auditing, purchase and property, editorial and information, files, library, and miscellaneous services and records.

(b) AGRICULTURAL CHEMICAL INVESTIGATIONS

Appropriation Act, 1941	$379,606
Budget Estimate, 1942	342,664
Decrease	36,942

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)	Decrease
1. Cereals, fruits, vegetables, and other agricultural products	$173,371	$143,922	$126,980	-$16,942 (1)
2. Sugars, sirups, and oils investigations	117,928	117,280	97,280	- 20,000 (2)
3. Protein and nutrition investigations	27,960	27,960	27,960	---
4. Basic investigations in the chemistry, microbiology, and pharmacology of agricultural products	50,188	64,835	64,835	---
5. Chemical weed eradication investigations	16,792	11,000	11,000	---
6. Enzyme action in agricultural products	12,459	14,609	14,609	---
Unobligated balance	12,802	---	---	---
Total	411,500	379,606	342,664	- 36,942

DECREASES

The reduction of $36,942 in this item for 1942 consists of:

(1) A decrease of $16,942 under Project 1, "Cereals, fruits, vegetables, and other agricultural products", due to the transfer of investigations on the freezing preservation of fruits and vegetables from the Seattle, Washington, Laboratory to the Western Regional Research Laboratory, Albany, California, since consumption of fruits and vegetables in frozen form is a "new scientific, chemical, and technical use."

(2) A decrease of $20,000 under Project 2, "Sugars, sirups, and oils investigations", due to the transfer of investigations on the utilization of sweetpotatoes to the Southern Regional Research Laboratory, New Orleans, Louisiana, since this is one of the commodities assigned to this laboratory.

Both of the above-mentioned lines of work, now carried under the item "Agricultural Chemical Investigations", will hereafter be financed from the appropriation "Conservation and Use of Agricultural Land Resources, Department of Agriculture (New Uses and Markets for Farm Commodities, Regional Laboratories)."

WORK UNDER THIS APPROPRIATION

General. This work pertains to present uses of and present products from food and feed crops. Its purpose is to increase farm income by solving problems (indicated by the following statements) which cause loss of value of crops or which interfere with their consumption along established lines, and to prevent deterioration in the quality of products which must be stored and saved under war and emergency conditions. Its specific objectives are as follows: To devise means of reducing deterioration of agricultural commodities between harvesting and processing and, in some cases, after processing; to reduce handling and processing costs; to determine the relative suitability of various processing treatments in relation to crops grown under various agricultural conditions; to determine the effects of storage of crops and to devise methods to reduce losses resulting from deterioration during storage; to adapt processing methods to newly introduced crops and to crops raised primarily for the fresh produce market; to render technical assistance to farmers' cooperative processor organizations; as a means of promoting national defense, to assist in developing "deficiency" crops (e.g., tung nuts for tung oil production), the output of which in this country does not nearly supply domestic requirements and for which the most urgent need is to improve the efficiency of handling, preparing, and processing the crop and to increase production; in cooperation with the Bureau of Plant Industry and State experiment stations, to select the varieties of crops best suited for specific forms of preservation in given areas, e.g., crops which may be grown profitably on lands newly opened by irrigation; to conduct chemical investigations necessary for developing new crops (including drug crops) from uncultivated or imported plants; to determine the composition and value of feed crops and thus to obtain a suitable balance in farm production programs; to devise methods for preventing contamination of foods and feeds (in raw materials and during processing) by substances detrimental to health; to solve problems in improving quality and obtaining greater suitability to market requirements after processing; to investigate atmospheric pollution which causes injury to crops and farm animals and to assist in devising means for its control; to develop chemicals suitable for weed eradication. Investigations are also conducted on far-reaching chemical, nutritional, enzyme, microbiological, and pharmocological problems which are basic to practically all crops and the solution of which would at once open the way to far-reaching applications of great importance to agriculture. These investigations are conducted

in cooperation with appropriate agricultural agencies.

Project 1. Cereals, Fruits, Vegetables, and Other Agricultural Products.

Objective: In order to increase the average returns to growers, investigations are designed: To devise methods for reducing deterioration of these agricultural products between harvesting and processing and after processing; to devise means for reducing handling costs; to determine the relative suitability of varieties and strains of fruits and vegetables grown under different agricultural conditions for various standard methods of processing; to determine the effects of storage on various agricultural products and to devise methods to reduce losses resulting from deterioration in storage so as to reduce loss of value to producers; to adapt processing methods to the specific requirements for newly introduced crops and for crops raised primarily for the fresh produce market; to render technical assistance to processors particularly farmers' cooperatives, so as to enable them to use more of the growers' crops. All activities are planned with the purpose of directly or indirectly increasing the return to growers from these commodities along present lines of consumption as foods and feeds.

The Problem and Its Significance: The substitution of the combine harvester for the reaper and binder (thereby eliminating certain beneficial changes which occur during "sweating" of grain in the shock) has materially altered the character of various grains as stored. It is important to determine the influence of harvesting wheat and other cereals by a combine on deteriorative changes during storage. Recent and present conditions have required the storage of large amounts of grain over periods longer than those customarily used in the past. Various deteriorative changes in cereals occur during storage. These changes are of great importance to farmers because of the desirability of preventing stored cereals from being forced on the market under conditions which would mean loss of value to the producer, as well as enabling the farmer to hold his stored grain for a better market when that course is deemed advisable. The subject is also important to the entire country from the standpoint of carrying over surplus cereals from years of excess production to years of deficient production, and thus more nearly balancing supply and demand. Of even greater importance is the desirability of devising storage methods which will ensure adequate supplies of cereal products in case of war or other emergency conditions.

It is urgent from the standpoint of both farmers and consumers that the nature of the various deteriorative changes which occur in cereals stored for such longer periods be determined and that means of restricting these deteriorative changes be devised. The effect of such deteriorative changes on byproduct feeds from cereals subjected to long storage is also of importance to the farmer.

By "compressing" flour, i.e., by eliminating air which is ordinarily intimately intermingled with it, the over-all volume can be reduced by one-third. Further compression may also be feasible. Shipment of flour in compressed form is important for conserving space in transportation for military use and for export. It is important to investigate this subject more fully and at the same time determine the effect on the quality of the flour which is produced by varying degrees of compression. There is evidence that deterioration of flour during storage can be materially reduced by "compression."

In certain areas fruits and vegetables of a type primarily suited to the requirements of the fresh produce markets are grown. The use of customary methods of processing, when applied to such fruits and vegetables, frequently results in products which are not commercially acceptable, e.g., when canned by customary procedures, they frequently do not have attractive color, flavor, and texture. Consequently, growers experience considerable loss because of inability to process end-of-the-season fruits and vegetables which cannot be sold satisfactorily on the fresh produce market. There is an acute need for making necessary changes in present processing methods so as to render them suitable for preserving this latter portion of fruit and vegetable crops.

Since varieties and strains of fruits and vegetables developed for special purposes, such as canning, tend to revert to undesirable types, it is necessary from time to time to develop new strains for this purpose and also to develop varieties or strains which will grow under special conditions, as in lands in the West newly opened to irrigation. The suitability of such varieties and strains of fruits and vegetables for processing purposes must be thoroughly tested before they can be adopted by growers. New fruits and vegetables, tropical and sub-tropical, have been brought into cultivation in the Southern part of the United States during recent years. Many of these products cannot be shipped in fresh form and, for commercial success, it is indispensable that processing methods be adapted to their special requirements. Thus, there are two methods of procedure which are followed simultaneously, i.e., (1) adaptation of processing methods to varieties, and (2) development of varieties which are more suitable for processing. The work here outlined includes the first procedure and also involves the second procedure through processing tests conducted in cooperation with appropriate agricultural agencies.

Frequently deteriorative changes which seriously impair the suitability of fruits and vegetables for processing occur during the interval between harvesting and processing. This loss in value falls almost entirely on the farmer, either directly or indirectly. Information now available indicates that such deteriorative changes, and loss of value, can be greatly reduced. This is a serious problem now confronting growers in many sections of the country.

Dehydrated food products necessarily play an important part in the rations of the Army and Navy, and the contemplated great increase in the military forces of the United States emphasizes the desirability of improving the quality of dehydrated fruits and vegetables. As [illegible]

prepared, such products have suffered serious impairment of vitamin content and it is important that a method of dehydration be developed whereby retention of vitamins can be increased. Work on improvement in methods of dehydrating fruits and vegetables has been informally requested by representatives of the Office of the Quartermaster General of the War Department.

Approximately six million bushels of cucumbers, valued at about $5,000,000 are used annually in the United States for production of pickles and pickle products. The losses in the industry due to spoilage of salt stock, the development of "bloaters", and other causes, amount to approximately $850,000 annually. These losses can be materially reduced. Production of cucumbers in various areas in the Southern states h s increased materially in recent years. Production in North Carolina is now about seven times what it was during the period 1928-1932, and this State is now the fifth largest producer of cucumbers in the country. Part of the cucumber crop in the South naturally moves into consumption in the fresh form, but a considerable proportion of the crop, which cannot be absorbed by the fresh produce market, is available for salting and conversion into pickles. However, the pickling methods commonly used in the Northern states are not satisfactory in the South on account of climatic conditions. This situation makes it necessary to work out changes in the existing pickling methods so as to render them suitable for Southern climatic conditions.

The average annual domestic production (1931-1935) of eggs is reported at 31,967 million, with a value of nearly $431,000,000. Part of the eggs is consumed rapidly but a large amount goes into storage. The trade estimates that about 5% are a total loss due to bacterial action. In addition, there is a loss of large magnitude due to reduction in price of eggs resulting from a degree of deterioration not sufficiently great to require destruction of the product. Improvements in handling methods and storage conditions, and the use of better containers will reduce both types of losses and will result in greater remuneration to the producer.

Plan and Progress of Work:

Work at present is conducted along the following lines:

(a) Cereals, seeds and byproducts: The effect of prolonged storage on the quality of wheat is determined by bread making tests on flour made from wheat stored under known typical conditions for varying periods. Comparisons are also made between flours from "combine"-harvested wheat subjected to extended storage and flours from wheats harvested by reaper and binder and stored for the same periods. In addition, chemical examination is made of wheat, flour, and bread in order to ascertain the nature of the deteriorative changes which have occurred and to devise means for controlling them.

Deteriorative effects occurring in flour under various climatic and other conditions is of particular importance at this time in connection with supplying the military forces of the United States and

for shipment abroad. The investigation includes development of modifications of standard bread formulas to improve quality and to facilitate the use of stored flour and of flour from stored wheat. This work on deterioration of cereals is being coordinated with investigation of suitable structures for long time storage. The effect of longer storage of cereals on the quality of byproduct feeds is also being investigated since this is a matter of much concern to farmers.

Investigation is being made of the effect of "compression" of flour (i.e., removal of finely intermingled air) on its use in bread making and to determine the value of this procedure as a method of storage to conserve space and reduce deterioration during storage. There is evidence that deteriorative changes, as well as space requirements, can be reduced by such treatment. This subject is of great importance at this time in connection with the storage and transportation of flour for use by the Army and Navy and also for shipment abroad. The facilities of the Baking Laboratory and the services of the specialized personnel will, as usual in the past, be made available to other governmental agencies which have need of baking tests and similar chemical work pertaining to cereals and cereal products.

(b) Fruits, vegetables and byproducts: Work is being conducted to adapt methods of processing to the specific requirements of fruits and vegetables characteristic of various areas and to test new strains which are being produced by plant breeders for suitability for processing by different methods. An investigation is being conducted to adapt processing methods to the tropical and sub-tropical fruits and vegetables which are coming into bearing in the Southern areas. Studies are being conducted to develop methods of maintaining the quality of fruits and vegetables between time of harvesting and processing. These involve investigation of the effects of temperature, active and inert gases, and similar treatments. Methods of processing fruits and vegetables are being investigated with the object of improving color, flavor and texture of the products.

The studies of processed fruits and vegetables are being continued to ascertain and eliminate the causes of deterioration after processing. In these various areas technical help will continue to be given to farmers ' cooperative processing plants. These organizations encounter many technical problems which are difficult or impossible for them to solve without assistance.

Work on the improvement of methods of dehydration of fruits and vegetables is being emphasized in view of the increasing importance of such products in the rations of the greatly expanding military forces of the United States. Especial attention is being given to improvements whereby the original nutritive constituents, including vitamins, may be retained unimpaired to a much greater extent than formerly. Work along this line has been planned after discussion with and at the informal suggestion of the Office of the Quartermaster General of the War Department. During the first World

War, large quantities of dried fruits and vegetables were produced for use by the Expeditionary Forces. These were useful but did not contain all the original nutritive ingredients, especially the vitamins, of which, at that time, little was known.

Experience has shown that a given strain, or variety, of fruit or vegetable does not produce crops of the same quality in different areas and that it is necessary in each area to select carefully the varieties which are suitable for growing in that area for processing purposes. Failure to make a proper selection means inevitable loss to the grower. Investigations along these lines are conducted in different areas in all cases in cooperation with appropriate state or federal organizations. These investigations make it possible to advise growers of the suitability for processing of the various fruit and vegetable varieties and strains under the conditions in which they are particularly interested as, for example in the Northern areas, which will soon be put under irrigation.

The use of ethylene for promoting the maturity of citrus fruits and other fruits and vegetables, for breaking the dormancy of deciduous fruit trees, for facilitating the hulling of English walnuts, and for other purposes, has been a development under this project. Based on statements from competent sources, the increased value of crops due to the use of this gas is estimated at not less than one and one-half million dollars annually, and the amount is increasing as new applications are found. Several improvements in methods of processing fruits and vegetables which have been developed as a result of this work are now in extensive use.

In cooperation with the North Carolina Agricultural Experiment Station, an investigation was begun at Raleigh, North Carolina, for the purpose of developing methods for handling, salting and fermenting cucumbers so that commercially acceptable pickles could be produced under climatic conditions prevailing in the South. Work completed to date has already enabled the investigators to advise operators how to overcome a number of the difficulties which have occurred in pickling plants in the South. Specific suggestions as to improved methods of pasteurization for pickled products have also been published for the benefit not only of the Southern branch of the industry but also for those who operate in the Northern states as well. As a direct result of this work, pickling of cucumbers is being developed commercially in the South.

(c) Eggs: An investigation is being conducted to determine the kinds and amounts of bacterial organisms in eggs and the effect of processing and storage on these microorganisms. Studies are being made of the bacterial contamination of eggs caused by the fillers for egg crates and by other sources, and attempts will be made to eliminate such contamination. The possibility of reducing the number of microorganisms in eggs prior to processing will also be investigated.

Project 2. Sugars, Sirups, and Oils Investigations:

Objective: To devise chemical and technological methods for reducing deterioration of sugar-bearing crops between harvesting and processing; to adapt and improve methods of processing sugar-bearing crops so as to improve quality and obtain greater suitability of processed products to market requirements; to render technical assistance to farm cooperative organizations which are processing sugar-bearing crops; as a means of contributing to national defense, to assist in developing "deficiency" oil crops (e.g., tung oil and other drying oils), the output of which does not nearly supply domestic requirements and for which the most urgent need is to improve the efficiency of handling, preparing, and processing the crop, and to increase production so as to supply the requirements of essential industries.

The Problem and its Significance: Raw sugar constitutes most of the continental production of cane sugar, whereas the financial return to sugarcane growers can be increased 50 cents or more per ton of cane if direct-consumption white sugar is made instead. There is an ample market for such sugar in sections contiguous to the areas of sugarcane production. The problem involved is to develop processing methods which are suitable for existing plantation sugarhouses in the continental sugarcane area.

A serious problem in the continental sugarcane industry is the damage to harvested sugarcane caused by cold weather during the latter part of the harvesting season, which causes deterioration with direct loss of sugar in the cane and also inability to extract the normal percentage of the remaining sugar by the usual processing methods. Serious loss of sugar also occurs in sugarcane stored at normal temperatures between harvesting and processing. Such storage is necessary in order to insure a continuous supply of sugarcane to the plantation sugarhouse during bad weather conditions which render the fields impassable.

Because of non-uniformity in quality, some food industries (e.g., canning, preserving, confectionery, sweetened condensed milk) in the beet-sugar producing areas have not used beet sugar for all their requirements, and this has caused a disadvantageous and wasteful cross-haul of cane sugar into beet-sugar areas and of the displaced beet sugar to outside points, with resultant serious increase in freight costs. The Mountain States Beet Growers' Association has estimated that, if the freight absorption cost on beet sugar (distributed pro-rata to growers under existing contracts) could be reduced 50 percent, increased returns to growers would average $6 per acre. In order to correct this situation it is necessary to improve the quality and correct the non-uniformity of beet sugar, which results, to a considerable extent, from variation in the composition of sugar beets in different areas.

Between harvesting and processing, about 50 percent of the sugar-beet crop is stored for an average of 40 days, during which time the sugar content is decreased by a total of about 180,000,000 pounds,

valued (at 3 cents per pound) at $5,400,000 annually. Such storage is unavoidable because of the necessity for digging all beets prior to freezing weather. Solution of such difficulties is indispensable to the efficient handling of these crops as sources of farm income and means a definite increase in financial return to the farmer for these crops.

About 40,000,000 gallons of farm-made sugarcane, sorgo, and maple sirups are produced annually as important small-farm cash and subsistence crops on some 500,000 farms in the United States. These crops are very useful in the small farm crop diversification scheme, and by far the greatest portion of this production originates on small farms, which are widely distributed geographically in this country. These crops also afford an opportunity to use family labor in a remunerative way. There is a further advantage in that harvesting and processing are both done on the farm during a period of the year when labor is not needed elsewhere. These farm-made sirups, although constituting a minor crop as compared with cotton, corn, wheat, etc., play a very important role in the economy of what may be termed "under privileged" families operating small farms throughout the United States. About 65 percent of the total production is marketed as an important source of cash but, because of variability in quality, the farm price varies as much as 300 percent from low to high grade and some sirup is unmarketable. On the other hand, there is an excellent demand for farm-made sirup of good and consistent quality, and hence there is an ample margin for the market absorption of considerably more farm-made sirup of acceptable quality than is now produced. The essential difficulty with these farm-made sirups (particularly sugarcane and sorgo sirups) is their variation in quality in comparison with the uniformity of competitive factory blended sirups. Correction of this situation is imperative for the success of these small-farm crops in competition with commercial blended sirups.

The annual production of honey in the United States is about 160,000,000 pounds, with farm value of about $12,000,000; about 5,000,000 colonies of bees are kept by nearly 1,000,000 honey producers. Per capita honey consumption in the United States for table use has declined. Food industries, which have used honey with satisfactory results and which would like to use greater amounts, have been prevented from expanding their consumption by inability to obtain consistently honey of desired type and characteristics. This is due to variation in composition and properties of honeys of different floral types, and particularly to the fact that domestic honeys never have been classified from this standpoint. Systematic classification of domestic honeys by types, on the basis of predominant chemical composition and characteristic properties, is indispensable in order that large consumers may be able to obtain honey of desired characteristics at all times. An important necessity for maintaining existing markets for honey is the improvement of methods of handling and processing this commodity so as to prevent deterioration during storage and to secure and maintain a satisfactory appearance

in comparison with competing products. Maintenance of the honey industry in satisfactory status is important, not only as a source of income to beekeepers but also because of the peculiar value of the honeybee in the pollination of crops (estimated at 15 times the total value of the honey produced), and particularly its indispensability to the fruit industry. Bearing of fruit trees is dependent on pollination, which in many cases is brought about almost entirely by honeybees.

Although the group of carbohydrate substances known as "hemicelluloses" constitutes up to 35 percent of the dry substance of animal feeding materials, it is a remarkable fact that the function and value of this group of constituents in animal nutrition has remained practically unknown. Obviously, considering the importance of feed crops in the farm production program, it is important that the function of this group of constituents be determined and evaluated, if possible. Recently, an important clue to the function of these constituents in the feeding of animals has been obtained and it is believed that investigation of the subject along the lines indicated by this clue will lead to a radical revaluation of feed crops with a resultant shift in farm production programs of much benefit to farmers. The information so far obtained indicates that the group of hemicellulose substances plays a much greater part in animal nutrition than has been supposed heretofore and that consequently all feeding materials and farm programs for their production should be revaluated from this standpoint.

Establishment of the domestic tung oil industry in the South (now in the early stage of development) on a basis which will be profitable to growers requires determination of the influence of varietal, cultural, and environmental factors on the yield and quality of oil obtainable, on the development of better methods of handling the crop between harvesting and extraction of oil, and on the more efficient recovery and purification of the oil. Solution of these problems is indispensable to the development of this industry which, because of the strong probability of decreased availability of tung oil from China, must supply more of the domestic requirements for this oil. The urgent need in this industry is to improve its general efficiency so as to increase the return to growers and at the same time increase the production of this important drying oil, which is now greatly needed for various uses, including use by essential industries important for defense requirements. Most of the tung oil used in the United States is imported from China. Information is also greatly needed relative to the chemical composition and properties of other drying oils from plants which hold promise of being developed into valuable crops in this country.

The Navy consumes annually a large amount of hard waxes, practically all of which is now imported. Because of the strong probability of interruption of these imports, a request has been received from the Navy Department that an attempt be made to recover

sugarcane wax as a byproduct of cane sugar production. Sugarcane wax has the properties desired and the amount which is potentially available in the United States and dependencies would be sufficient to supply the Navy's requirements.

"Rancidity" is the most important of the deteriorative changes which take place in oils and fats and is common to food products containing them. The annual value of the products subjected to rancidity is at least two billion dollars. Losses due to reduction in quality and in selling price total many million dollars annually. Solution of this problem will permit longer storage of oils and fats and foods containing them, thus reducing the necessity of selling by the producer regardless of market conditions. It is of value to consumers as well as producers and is especially important in connection with the storage of foods for military use.

Plan and Progress of Work:

Work at present is conducted along the following lines:

(a) Beet and cane sugars: A method has been devised whereby deterioration of sugarcane (loss of sugar) during storage at normal temperatures between harvesting and processing can be largely prevented. The identity of a substance which separates from sugarcane juice during processing of the cane and which has caused great difficulty in processing certain otherwise desirable sugarcane varieties has been established and a method for controlling this difficulty has been devised. A method has recently been devised for recovering this substance (aconitic acid) which, while objectionable in the sugar process itself, has turned out to be a valuable byproduct of considerable future value to the cane sugar industry, since it has an important use in the manufacture of plastics. Work is now in progress on methods for producing direct-consumption white sugar with existing equipment in the plantation cane sugarhouses in the continental United States, and on methods for minimizing loss of sugar in the harvested cane which is exposed to cold weather. Loss of sugar in harvested cane during a "cold spell" is one of the most serious problems of the continental sugarcane industry, and it is indicated by recent results that it will be possible to develop means whereby this damage can be very greatly restricted.

As a direct result of the work under this project, the variation in quality of beet sugar (which is due in considerable measure to variations in the quality of sugar beets) is being reduced, and a continuously increasing percentage of beet sugar is being used in sugar-beet areas by industrial consumers (e.g., canning, preserving, confectionery, sweetened condensed milk) who formerly used it only in minor quantities, if at all. This result is being reflected in a corresponding decrease in freight absorption costs for shipping beet sugar to distant points, thus increasing the net pro-rata return (based on the net price at which the sugar is sold) to sugar beet growers under existing contracts with processors. (See under "The Problem and its Significance").

An investigation is being conducted to ascertain the causal factors which are responsible for the tremendous loss of sugar in sugarbeets (see under "The Problem and its Significance") during the present necessary period of storage prior to processing and to devise means of preventing or greatly restricting this loss. This loss of sugar is the more important because the full expense of the production and harvesting of the sugar beets has already been incurred by growers. Solution of this difficulty would mean a great saving to the sugar-beet industry and would increase very materially the income of farmers from this crop. Most of this sugar loss occurs while the crop is stored in the hands of growers. Furthermore, under the terms of processor contracts with growers, the final payment for sugar beets is based on the quantity of sugar recovered and the price obtained. Hence, this loss falls primarily on the farmer.

A process has been developed for production of sugar from sorghum. This is a problem of long standing, having previously been worked on by various investigators without success. The new process depends upon the separation of starch and aconitic acid (both of which are valuable byproducts), after which the process can be operated in the same manner as for the production of cane sugar.

(b) Farm-made Sirups: The Bureau has devised a method, now in extensive use, for preventing the "sugaring" of sugarcane and sorghum sirups, which heretofore has caused a price penalty to the farmer up to 15 cents per gallon or, in some cases, has rendered the product unmarketable. The Bureau has also devised a method for preventing the "jellying" of sorghum sirup, which heretofore has been the cause of the selling of large quantities of this farm-made sirup at "distress" prices. This method is now in extensive use. The marketability of these sirups has been greatly improved by these methods. Plans and specifications for farmers' cooperative sirup plants, embodying important improvements in processing technique developed in this work, have been prepared, and a large number of such plants have been erected by individual farmers and by farm cooperative associations. Work is now under way on the development of means for standardizing the color, flavor, and clarity of farm-made sirups. In cooperation with appropriate agricultural agencies, investigations are under way for determining the effect of different varieties of sugarcane and sorghum and of factors such as soil and fertilizer, on the quality of sirup obtainable from sugarcane and sorghum cane under these various conditions. The information thus developed will be of far-reaching importance in making it possible for farmers to produce sorghum and sugarcane sirups of uniform and desirable quality.

Because of the lack of system and looseness of grades in marketing maple sirup and the fact that grading facilities have not been available to the producer, an improved system for grading maple sirup has been devised. Master grading standards are prepared each year and distributed to officials in maple-producing States. These officials then prepare sets of grading standards for distribution to

producers. These standards were recently adopted by the Agricultural Marketing Service for use under the law authorizing establishment of grades for agricultural commodities. A method of producing a natural maple flavor concentrate has been developed whereby producers are able to obtain a better return for the lower grades of maple sirup and sugar. This method is in commercial use.

(c) Honey: This work has resulted in the development of an improved process for clarifying honey which is now extensively used throughout the United States and which prevents "granulation", causes better retention of flavor, removes emulsified air and suspended material, and yields a clear product of attractive appearance. This process permits the packing of honey in containers of any desired type and increases the marketability of honey by improving its appearance and keeping quality, Means have been devised for controlling the content of the enzyme, diastase, in blended honey, which was previously an obstacle to export business. Previously, the principal importing countries required the examination of all honey offered for import for the purpose of determining the quantity of the enzyme contained therein (as a criterion for detecting objectionable methods of processing honey), and honey shipments were refused entry whenever the diastase content was found to be too low. An investigation is being conducted to determine the chemical composition and properties of the various floral types of honey produced in the United States in relation to the characteristics required for various uses (as in the baking, confectionery, and preserving industries). Several food industries consume honey at the present time and would like to use more, but have been hampered by difficulty in consistently obtaining supplies of honey with the characteristics which have been found to be satisfactory for their purposes. By determining the predominant chemical composition and characteristic properties of the various floral types of honey available in the United States, and thus "earmarking" them, it will be possible for large consumers to obtain consistently the required quantities of honey with the particular characteristics required for their purposes, thus contributing to stabilization of the market for honey.

(d) Hemicelluloses: A systematic investigation is being made of the quantity and characteristics of the hemicellulose substances in various feeding materials, particularly those which are of gre test importance in animal feeding. The importance of this investigation is indicated under the foregoing heading "The Problem and its Significance". Animal feeding tests will be conducted (in cooperation with Bureau of Animal Industry) for the purpose of evaluationg individual hemicellulose substances and thus determining the importance of these constituents of feedstuffs in animal nutrition. Important new information has been developed relative to the composition of the hemicellulose substances in alfalfa, timothy, and Lespedeza, particularly in relation to feeding value at different stages of growth and harvesting. It is expected that the data obtained will be made the basis for recommendations which will have a far-reaching effect on selection of feeds and the proper

apportionment of feed crops in the farm production program. There is strong reason to believe that at the present time many feeding materials are improperly valued and that either too little or too much stress is being placed on certain feed crops in the scheme of farm feedstuff production. Accurate knowledge along this line will certainly mean a financial saving to the farmer in animal feeding.

(e) Oils, fats, and waxes: In investigations for assisting the development of the tung oil industry in the South, the Bureau has devised a method of solvent extraction of oil from tung nuts which increases the yield considerably and which may also reduce materially the cost of extracting the oil. The residual materials, after extraction of oil by the customary method (expulsion by an oil mill), is toxic to animals. On the contrary, the residual material, after solvent extraction of oil, is less toxic and has possibilities of being used to advantage as a feed, thus constituting a source of income. Methods are being developed for completely eliminating toxic action, and feeding tests are being conducted in cooperation with State experiment stations. Solvent extracted oil has usually been dark in color and subject to the disadvantage of undergoing partial solidification during storage. A method has been developed for preventing these difficulties.

Improved methods for drying, hulling, and storing tung fruits between harvesting and processing are being developed, and means are being devised for reducing or preventing the deterioration of the oil during this preliminary storage period. In cooperation with the Bureau of Plant Industry, an investigation is being made on the influence of environmental factors such as climate, soil, and fertilizer on the yield and quality of tung oil. These factors have great influence on both the yield and the quality of oil obtainable and their evaluation will be of great importance in developing the tung oil industry in this country.

In recent years imports of tung oil have increased greatly, reaching a maximum of 175 million pounds in 1937. On account of conditions in the Orient, particularly in China, imports in 1940 have fallen to about one-third of this amount. The development of this new industry in the United States is being guided by the results of studies carried on in the Department. Estimates for 1940 indicate that domestic production will be equal to about one-tenth of the imports.

An investigation of linseed oil from different varieties of flax is being made to determine which of the hardier varieties of this crop can be used advantageously in the United States. An investigation is being made of drying oils from subtropical crops which hold promise of being grown successfully in the southern part of the United States, as a means of increasing the domestic supply of drying oils, which is at present not adequate for our needs and which is indispensable to essential industries important for defense.

The United States is now very largely dependent on foreign sources for drying oils, but importation from some of these sources (particularly Asia) might readily be interrupted in view of the present international situation.

An investigation is being conducted for purpose of devising methods of extraction and purification whereby sugarcane wax can be recovered as a byproduct of cane-sugar production. The Navy uses a large amount of hard waxes, which are now imported, and in view of the great probability of interference with these imports because of international complications, the Navy Department has recommended that a domestic source of supply be developed. Sugarcane wax has the desired properties and the amount potentially available in the United States and dependencies would be sufficient to supply the Navy's needs.

As a means of evaluating the factors which cause rancidity, the composition of fats and oils is being determined after exposure to various conditions which cause this result. Investigation of the effect of light on the development of rancidity is being continued and from these studies better packaging and storage methods and materials are being developed. Some of these improved packaging methods are now in commercial use. New tests to replace the present unsatisfactory tests for rancidity are being devised, which, it is expected, will result in improvements in the storage and marketing of oils and fats and the food products containing such oils and fats.

Project 3. Protein and Nutrition Investigations:

Objective: To conduct chemical and biological investigations on proteins, amino acids, and vitamins in order to ascertain the nutritional value of foods; to determine the effect of storage and industrial processes on the nturitional value of grains, meals, and other agricultural products; to determine the properties, amino acid composition, and digestibility of food proteins in order that amino acid deficiencies in one foodstuff may be corrected by proper supplementation with other proteins so as to provide a balanced protein diet.

The Problem and its Significance: Proteins and vitamins are two of the most important factors in human and animal nutrition. Proteins differ greatly in their food value. They are complex compounds made up of over twenty constituents called amino acids. Ten of these are now known to be essential for growth and nutrition. When any one is lacking in the diet specific nutritional derangements result. The chief proteins of some of the most important foods are deficient in one or more amino acids; others contain them in abundance. Exact information on the amino acid composition of proteins is meager and fragmentary. Commercial processing and treatment of foods during their preparation may remove or destroy nutrient elements. It is

therefore important to determine the effects of such treatments on the nutritional value of the food factors involved.

Extension of our knowledge of the chemistry of proteins is important for the farmer for the efficient feeding of farm animals and for the best utilization of his food crops; for the correction of much of the nutritional deficiency prevalent among people in the United States resulting from inadequate protein in the diet with respect to both quantity and quality; for advancement in the fields of enzymes, serums, antitoxins, and immunization against disease. Large quantities of grain are stored under the provisions of the "Ever-normal Granary". It is known that during storage and aging striking changes occur in some of the properties of the proteins. It is of great importance to learn more about the nature and extent of those changes and of the effect they have on the value of the proteins for food and technological uses.

Large areas of land in the United States are rendered unfit for the growing of food crops, because plants grown on them absorb selenium from the soil. The selenium combines with the protein of the plants to form a toxic compound which causes great losses to farm animals. Erroneously, these losses have been oftentimes locally ascribed to "alkali disease". Besides the losses to farm animals, grain grown in these areas sells at a discount which sometimes runs as high as 50 percent. Knowledge of the nature and properties of this compound would be of great value in dealing with this problem.

Plan and Progress of Work: Authentic samples of source materials (grains, seeds, and other agricultural products) are obtained in cooperation with the Agricultural Marketing Service, State agricultural experiment stations, and individuals. Studies are made on the nutritional properties and composition of their isolated proteins, their digestibility, and amino acid content. Feeding experiments are made on the proteins of grains (corn, soybeans, wheat, and peanuts) in order to determine the vitamin content of foods and to study the methods of vitamin technique and the stability of vitamins. Chemical and biological investigations are made on products of unknown food value in order to ascertain their suitability for use in human diet or as feed for farm animals. Grains, seeds, and their milled products are stored under different conditions, and studies are made of the changes that occur in the chemical and nutritive properties of their proteins. Processed foods are studied in order to determine the effect of heat, bleaching agents, and other treatments upon the chemical and nutritive properties of their proteins. Improvements in the methods of separating and purifying proteins and of determining amino acids are investigated.

A study is made of the properties and chemical structure of the organic selenium compound occurring in "toxic" wheat and other plants grown on seleniferous soil areas. A crystalline compound

has been isolated which represents a hitherto unknown type of amino acid containing selenium. This discovery opens up an entirely new field in protein and amino acid chemistry, which will be of great significance in plant and animal metabolism and will contribute to the elucidation of the question of the structure of proteins.

Experiments covering several years have shown that the proteins in yellow corn are "complete", that is, they contain all the essential amino acids, the building blocks for animal muscle. Previous experiments, which apparently did not supply adequate vitamin values, have indicated that corn was not a satisfactory source of protein for growing animals. In addition, a certain stigma is attached to corn based on the idea that it contributes directly to the development of pellagra. The removal of this idea, together with a dissemination of the knowledge of the nutritive value of corn, should expand the human consumption of corn about 90 million bushels and perhaps somewhat increase its use for animal feeding.

Project 4. Basis Investigations in the Chemistry, Microbiology and Pharmocology of Agricultural Products:

Objective: By means of chemistry and the sciences of microbiology, pharmocology, and microscopy, to solve basic problems of importance which underlie or are common to the storage, handling, and processing of many food and feed crops. Usually these problems concern all crops in a given area or are common to a large number of crops in different areas. Hence, the work is organized functionally rather than by commodities.

The Problem and its Significance: The commercial value of many agricultural products, particularly those used for foods, and, in some cases, those used for feeds, depends to a considerable extent upon color not only in fresh products but also in processed commodities. Lack of retention of attractive color in processed foods is frequently a serious obstacle to sales, and more of certain kinds of processed foods would unquestionably be consumed if the color were more attractive. Likewise, the return to the grower from raw materials would be greater. Knowledge of the chemical nature of the plant pigments responsible for color is a prerequisite to the adaptation and development of processes of preservation suitable for obtaining better retention of natural colors.

The flavor of fruits and vegetables is of much importance in a similar way in influencing the commercial value of these commodities. In many cases knowledge of the chemical identity of the constituents responsible for flavor serves immediately to indicate the precautions which it is necessary to take in processing in order to retain flavor in processed products.

Cooperative work in chemically identifying and determining the content of a variety of other specific constituents in fruits

and vegetables is frequently requested by other Governmental agencies and by State agricultural experiment stations. Considerable information has been requested by the Soil Conservation Service relative to the chemical identification of constituents of various plants recommended by that unit and other agencies for preventing soil erosion and improving soils, the idea being that for the same degree of effectiveness in preventing soil erosion it would be preferable to select plants capable of yielding useful products. In plant-breeding investigations for purpose of developing more suitable varieties and strains of fruits and vegetables, attractive color and flavor are essential factors and it is important in such work to determine the chemical identity of the substances to which color and flavor are essentially due. Cooperative investigations with plant breeders are conducted to determine the chemical identity of pigments and flavoring substances in the case of fruit and vegetable varieties which it is important to improve because of their non-suitability for the fresh produce market or for processing or because of their failure to maintain essential characteristics when grown in certain areas.

Losses to the farmer from damage by insects to his crops in the fields and during storage, as well as to farm animals, is well known. New insecticides and fumigants are being sought continuously. Before the use of these new products can be recommended it is necessary to determine the effect on the consumer, human or animal, of food and feed commodities so treated and also upon those who apply such insecticides and fumigants.

Technological changes in the handling, preparation and processing of agricultural commodities frequently result in the introduction into foods and feeds of contaminating substances not heretofore present, and it is necessary to determine possible effect on human and animal consumers before such changes can be recommended.

Sometimes forage and other crops naturally contain toxic substances such as hydrocyanic or prussic acid or other organic compounds produced by plants in connection with their growth, or compounds of poisonous elements such as fluorine, selenium, or barium derived from the soil. Serious losses to farmers from poisoning of cattle occur from time to time from such causes. Appropriate pharmacological tests will indicate in advance the possible damage which might result from the use of such crops and will also check the efficiency of methods used to effect the elimination of such dangerous constituents.

The United States is now almost entirely dependent on foreign sources for indispensable drugs, e.g., opium derivatives, quinine, aloes (the principal constituent in cathartics). In view of the existing international situation, imports from Asia may be restricted or cut off. It is important from a defense standpoint that hemispheric sources for such drugs be developed in order to supplement imported supplies.

Science has demonstrated in comparatively recent years that, in addition to visible animals and plants, the world is densely populated with living matter too small to be seen with the unaided eye. This minute living matter consists of yeasts, molds, bacteria and other microorganisms. Some of them are beneficial to man, some are destructive, and some are the causes of many of the ills of plants, animals and man. Every agricultural commodity, without exception, is subject to the action of microorganisms which, if not controlled, may cause serious d mage or even destruction. Microorganisms are responsible for most of the farmer's loss of food and feed crops by spoilage. On the other hand, by appropriate selection of microorganisms and by suitable control of them many beneficial results can be obtained in the handling and processing of farm products. The science of microbiology is thus of far reaching importance and is indispensable to the scientific investigation of agricultural problems of many kinds, beginning with the selection and preparation of the soil and extending to final consumption of agricultural commodities of all types. The importance and unique value of microscopy as an aid in the solution of many agricultural problems by scientific investigation also has been well established. By microscopical examination it is possible to obtain an insight into many problems which arise in the handling, storage, and processing of food and feed crops and products therefrom.

Because of the widespread and far-reaching application of microbiological and microscopical methods to the scientific investigation of many agricultural problems and the unity of principle represented by the various procedures of examination of materials, it is much more economical to concentrate such investigations in one laboratory with specially trained personnel than to multiply such facilities in connection with the investigation of problems pertaining to the various agricultural commodities. This work is therefore organized on a "functional" rather than an agricultural "commodity" basis, but is applicable to all farm products which require investigation from this standpoint. This is the only Government microbiological laboratory which is devoted to the solution of problems relating to storage, deterioration, processing, and preservation of food and feed crops.

For some years the gases, fumes, and dusts from smelting and other metallurgical operations have caused serious direct damage to crops and indirect damage to farm animals grazing and feeding on these crops. In recent years the increase in capacity of metallurgical operations has enlarged the area of damage and the total injury to plants and animals. On account of the financial importance of the metallurgical enterprises and the varied and potent influence of the interests supporting them, farmers have in many cases been unable to obtain necessary protection through local agencies, and Federal assistance has been necessary. In some cases smelters near international boundaries have caused damages which have resulted in further activities on the part of the Federal Government. The most recent case is that of the Trail Smelter in British Columbia. Damages

from this smelter have been determined by an international commission and tribunal, and awards aggregating $428,000 have been made. Various instances of damage have been investigated from time to time in the past and valuable but sporadic information obtained. This investigation is being carried on in order to utilize fully the information at hand and to develop further information in a systematic way so that the interests of farmers and stockmen may be adequately protected. It is desirable to publish the results of the work that has been accomplished and to continue this investigation in areas where such contamination is still a pressing problem. In this way the Government will be able to assist those citizens who have no other sources of aid.

Plan and Progress of Work:

Work at present is conducted along the following lines:

(a) Chemistry of Agricultural Plants and Plant Products: Investigations of the chemical identity of the substances in fruits and vegetables which are primarily responsible for their color and flavor are being conducted. The importance of this subject is indicated in the foregoing under "The Problem and its Significance". This work is being correlated with work on the breeding of more suitable varieties and strains of fruits and vegetables with improved color and flavor characteristics which is being conducted by other agricultural agencies. The results of the work will also be applied to improvements in processing methods for purpose of better maintenance of color and flavor in fruits and vegetables after processing.

Chemical examinations of various plants and plant products are being made for the Soil Conservation Service in order to identify and evaluate useful constituents in plants which are being recommended for preventing soil erosion or for improving soils. This is being done with the objective of selecting, so far as possible, plants which are not only suitable for preventing soil erosion but which will have commercial value as a result of products obtained. Investigation of the chemical nature of various constituents is being made in the case of tropical and subtropical plants submitted by the agricultural experiment stations and by other agencies in Hawaii and Puerto Rico. Chemical identification and evaluation of various constituents are also made in connection with the development of crops from uncultivated or imported plants.

(b) Pharmacology: The work on pharmacology serves a variety of needs. As new insecticides and fumigants are developed by the Bureau of Entomology and Plant Quarantine, they are submitted for determination of their acute and chronic toxicity from the standpoint of effect on humans and animals. Those which have low toxicity are then tried out in field tests to determine their effect on insects and vegetation. After the new products have passed these tests they are recommended to growers for practical use. This procedure prevents one unit of

the Government from developing and recommending the use of an insecticide which another unit may find to be in violation of a regulatory law. The use of a recommended insecticide prevents loss to the grower which would result from the seizure, for law violation, of fruits or vegetables which carry dangerous insecticidal residues.

There is a definite possibility that sources of American substitutes to supplement indispensable imported drugs may be developed. As a defense measure and in view of the possibility of interruption of important imports particularly from Asia, cooperation with State experiment stations and other Bureaus of this Department is planned for the purpose of making necessary pharmacological tests of these drug products. This is the only pharmacological laboratory in the Department of Agriculture; hence it serves a variety of needs, including cooperative work with other units of the Department.

(c) Microbiology and microscopy: Investigations are conducted which are concerned with various phases of microbiology and microscopy as applied to food and feed crops and their products. Among the problems of diverse nature investigated for purpose of determining causes and devising preventive or corrective measures are: bacterial spoilage of hay, spoilage of raw and processed fruits and vegetables, botulism and food poisoning caused by bacterial toxic products, deteriorative changes occurring during the low temperature storage of eggs, microbiological deterioration of sugarcane damaged by cold weather (which causes both direct loss of sugar and indirect loss through changes which prevent extraction of the normal percentage of sugar), improved control and better application of beneficial types of bacterial action (production of sauerkraut, etc.) spoilage and deterioration of cereal products and concentrates during storage, application of beneficial types of microbial treatment to the production of foods and feeds in order to obtain certain desirable characteristics of quality.

This laboratory also makes examinations of food and feed crops and products for other units in the Department. It is expected that the cooperative activities of this laboratory will increase in connection with problems arising from the great expansion in scope of food supplies for the military forces of the United States.

(d) Effect of effluent contaminants upon plants: During the growing season field work will consist of the collection of samples of plant or other materials involved, the examination of the plants in the field, determination of the amount of contamination in the atmosphere, and such other biological studies as may be necessary. During the remainder of the year chemical and physical examination of the collected samples will be made in the laboratories in Washington. It is probable that the field work and the laboratory work will each require about one-half of the investigator's time. In

addition to this, and based on the past experience of the Bureau, it is anticipated that many calls for advice and assistance will be received, not only from individual farmers, but also from various farmers' cooperative groups such as Farm Bureau and Grange organizations. It is proposed to assist such groups of farmers in the technical problems involved in determining the nature and degree of acuteness of the atmospheric pollution hazard with which they find themselves confronted and to cooperate with them in devising means for their protection from constant or recurring injuries from this source.

Project 5. Chemical Weed Eradication Investigations:

Objective: To carry out chemical engineering, electrochemical, and economic studies leading to lower manufacturing and distributing costs of chemical agents suitable for the eradication of noxious weeds.

The Problem and its Significance: Weeds cost the American farmers hundreds of million of dollars annually through reduction of crop yields, quality of crops, and the value of farm lands. This loss is estimated to be three times the cost of ravages by insect pests and twelve times the losses from animal diseases. Noxious weeds are widely distributed and the area of infestation has been growing during the past decade. Organized State effort and the availability of cheap chemical herbicides have been found necessary to keep the noxious-weed area under control.

Plan and Progress of Work: Investigations have been made on the design, construction, and operation of electrochemical cells for producing sodium chlorate as a means of reducing the cost of this important weed-eradicating chemical. Economic studies have indicated the costs of production and distribution of sodium chlorate. Research is being conducted on the preparation of organic herbicides, with the view of developing less costly methods of weed eradication. The testing of new herbicides is carried on in cooperation with the Bureau of Plant Industry.

Project 6. Enzyme Actions in Agricultural Products:

Objective: To apply that body of knowledge known as enzyme chemistry, or enzymology, to the study of agricultural products during growth, ripening, storage, and decay; also to apply the class of chemical agents known as enzymes to useful purposes of agriculture and of industries based on agriculture.

The Problem and its Significance: All agricultural products are either living tissues or derived from what were living tissues. The chemical changes in tissues, whether alive or dead, are largely caused by the presence in the material of a number of substances called enzymes. These substances hasten the growth, ripening, and decay of tissue. In many cases enzymes are substances constructed by the cells, while

alive, out of certain vitamins -- a fact that indicates why these vitamins are important. Microorganisms contain enzymes. The effects of bacteria on food, etc., are due to the bacterial enzymes. When isolated from the tissues that produced them many enzymes continue to perform the same kind of chemical change as before. They thus become powerful chemical agents. For example, pepsin is a digestive agent in the stomach; it also digests meat in a factory for the making of peptone. Similarly, diastase is an enzyme that changes starch to sugar in sprouting barley. Made from malt, diastase does the same thing in the brewery and in the calico printery. Lipase is an enzyme that digests the fats eaten by animals. It is also able to digest the fat from hides in the tannery. Enzyme studies have two kinds of applications: First, because enzymes are responsible for both growth and decay, there are applications of enzymology to problems of growth, storage, and the preservation of agricultural products -- that is, to the conservation of agricultural products; second, because enzymes are chemical agents, they have certain applications to industry. The use of an enzyme has often improved a technical process. Before either kind of application can be made, however, it often happens that new knowledge of the action and nature of certain enzymes must be obtained. This requires so-called "basic" research in many cases.

Plan and Progress of Work: The Enzyme Laboratory attempts both to obtain knowledge about enzymes and to apply this knowledge, as outlined above. For example, a study of enzyme action in eggs resulted in a process known as the "vacuum-carbon-dioxide process" for the preservation of shelleggs in storage; also, in another process, for the quick liquefaction of egg white meant to be dried; also, in a third process, for the recovery of some egg white otherwise wasted. In the course of these studies it also became evident that the grade of an egg was temporarily lowered by the act of candling the egg. This fact explained many a dispute between buyer and seller.

A study of the enzymes of wheat and flour elucidated the hitherto unknown effect of chemical bread improvers and of many bleaching agents on flour. These studies led to a better understanding of the chemistry of flour storage and of bread making and to a new and valuable test for the suitability of a given flour. Industrial concerns frequently take over and finish the application of discoveries for which these investigations have furnished the basic information. Thus, the addition of malted grain to very hard flour (drought wheat) was based on the Bureau's discovery that this wheat lacked a proteolytic enzyme. Similarly, it has been shown that a rapid aging of combine-harvested wheat can be produced by ethylene. It has been shown that knowledge of enzyme action gained in one field is often more valuable in another connection than where it was first discovered. Because the principles of enzyme action are much the same for all agricultural products, it is planned to continue this work along the lines indicated above, without restriction to any one special commodity. For the immediate future, the work will be continued on cereals and cereal products.

SUPPLEMENTAL FUNDS

Project	Obligated, 1940	Estimated Obligations, 1941	Estimated Obligations, 1942
Arbitration of Smelter-Fumes Controversy United States and Canada (Transfer from State Dept. to Agriculture): For smelter-fumes investigations to determine damage to crops and forests in the State of Washington	$8,989	- -	- -

(c) INDUSTRIAL UTILIZATION OF FARM PRODUCTS AND BYPRODUCTS

Appropriation Act, 1941	$22,550
Budget Estimate, 1942	- -
Decrease	-22,550

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)	Decrease
Industrial Utilization of Farm Products and Byproducts:				
(a) Hides and skins investigations	$12,045	- -	- -	- -
(b) Tanning materials and tanning processes investigations	16,116	- -	- -	- -
(c) Leather investigations	7,480	- -	- -	- -
(d) Wastes investigations.	33,500	20,050	- -	- 20,050 (1)
(e) Biological stain investigations	425	- -	- -	- -
(f) Fermentation investigations	57,849	- -	- -	- -
(g) Lignin investigations.	8,900	- -	- -	- -
(h) Chemical conversion of oils, fats, and waxes	24,375	- -	- -	- -
(i) Plastics investigations	10,668	- -	- -	- -
(j) Motor fuels from agricultural sources	11,325	- -	- -	- -
(k) Harvesting, collecting, preservation, and transportation of agricultural residues	- -	2,500	- -	- 2,500 (2)
Unobligated balance	8,517	- -	- -	- -
Total appropriation	191,200	22,550	- -	- 22,500

DECREASES

The decrease of $22,550 in this item for 1942 consists of:

(1) A reduction of $20,050 due to the transfer of research on the utilization of agricultural wastes to the Northern Regional Research Laboratory, Peoria, Illinois. Inasmuch as the Northern Regional Research

Laboratory has included in its program a project dealing with industrial utilization of agricultural wastes, this important work will be continued at and financed from funds of that laboratory in 1942.

(2) A reduction of $2,500 due to the completion in 1941 of a survey of machinery and methods used in the collection, transportation, and preservation of agricultural residues. Inasmuch as these investigations are essentially of an engineering nature, it is proposed to carry out the program to be developed from this survey under the subappropriation "Agricultural Engineering Investigations." The funds required for such investigations in 1942 are accordingly included as an increase in the amount of $2,500, under Project 2, "Farm Mechanical Equipment Investigations" in the estimates for agricultural engineering activities, which follow.

WORK UNDER THIS APPROPRIATION

Originally, work under this appropriation dealt with investigations looking to the utilization by industry of crops, wastes, and byproducts of agriculture through the conversion of these agricultural products into industrial raw materials, intermediates, chemicals, and finished articles, such as tanning extracts, leather, cellulose, paper pulp, wallboard, plastics, and fermentation products; the substitution for industrial purposes of more profitable new crops; and improvement in the quality, production, preservation, and processing of hides, skins, and tanning materials.

Investigations of the type formerly conducted under this item will be conducted at the Regional Research Laboratories established pursuant to Sec. 202 of the Agricultural Adjustment Act of 1938, and will be supported by funds of such laboratories.

(d) AGRICULTURAL ENGINEERING INVESTIGATIONS

Appropriation Act, 1941	$304,469
Budget Estimate, 1942	321,950
Increase	17,481

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)	Increases
1. Advice and assistance	$23,362	$25,900	$25,900	- -
2. Farm mechanical equipment.	93,293	96,300	103,781	+$ 7,481 (1)
3. Farm structures and related investigations	83,594	78,900	78,900	- -
4. Mechanical processing of farm products	74,643	73,369	83,369	+ 10,000 (2)
5. Farm operating efficiency investigations	10,356	- -	- -	- -
6. Rural electrification investigations	28,265	30,000	30,000	- -
7. Dust explosion and fire prevention	29,659	- -	- -	- -
Unobligated balance	6,297	- -	- -	- -
Total	349,469	304,469	321,950	+ 17,481

INCREASES

The increase of $17,481 in this item for 1942 consists of:

(1) A net increase of $7,481 under Project 2. "Farm mechanical equipment", including:

(a) An increase of $14,981 to expedite the development of economical machinery for the production and harvesting of sweetpotatoes, as follows:

Objective; To develop methods and equipment whereby the farmer can economically grow and harvest sweetpotatoes for conversion into stock feed and starch.

The Problem and its Significance: Existing farm methods for sweetpotato production consist mainly of practices and equipment developed for the market gardener and result in high costs per unit of production. The

high labor requirements of the small acreages of this crop so conflict with other farm crops in seasonal requirements that farm adjustment is impossible with present methods. Accordingly, studies should be made to determine the most efficient methods and to develop better equipment for producing and harvesting the crop. The harvesting problem involves the reduction of damage and loss during digging which is now rather high.

In 1939 the United States imported 426 million pounds of starches of various kinds. Starch from the sweetpotato is an acceptable substitute for a considerable amount of these imported starches. Present production methods are, however, costly and time-consuming and, if sweetpotatoes are to become available in quantities necessary to supply starch factories and for use as stock feed, machine methods are necessary to lower the cost, particularly for transplanting and harvesting.

Plan of Work: Plots will be arranged upon representative soil areas to study the effect on sweetpotato yield as influenced by design of machinery and by methods used in tillage, planting, and harvesting operations as follows: (1) depth, character, and season of seedbed preparation in both level and ridged tillage; (2) methods of transplanting, including plant spacing; (3) rate, location, and time of placement of fertilizer; (4) depth, character, and frequency of cultivation; and (5) damage and loss during digging. Controlled studies will be made of sweetpotato production and harvesting machinery to determine the power and labor requirements and operation characteristics. Crop operations found to have (1) excessive labor requirements, (2) serious time conflicts with other farm crops, or (3) excessive crop losses will receive special consideration. Existing equipment will be improved and new machines developed as the need becomes apparent.

(b) An increase of $2,500 for investigations on machinery for the economical collection of agricultural residues, to be developed from a survey carried out in 1941, as follows:

Objective: To devise and develop methods and machinery for the economical harvesting, collecting, preparing for transportation, farm storage, and transportation of agricultural residues as raw materials for industrial uses.

The Problem and its Significance: Industrial utilization of agricultural residues depends on the procurement and availability of these raw materials in a clean, uniform condition at prices competitive with like industrial materials. With the exception of straw (approximately 500,000 tons a year), this situation has not been met and, because of the harvester combine, even the straw-board industry is being hard pressed to secure sufficient low-priced straw. This collection problem must obviously be solved before tonnage use of agricultural raw materials moves into industrial channels.

It is estimated that 100,000,000 tons of agricultural residues are

Northern Regional Research Laboratory has been assigned the development of industrial uses of these agricultural residues. Obviously, these residues must first be collected in a condition to meet industrial specifications for cleanliness and physical condition and at a competitive cost. Present methods of harvesting are little concerned with the use of such residues, and indeed the harvester combine takes no account of producing straw for either industrial or farm use. Straw being produced for straw board contains much chaff and dust, actually increasing transportation and processing costs. Farm equipment manufacturers are awake to the situation and realize that they or other agencies must develop machinery suited for collecting residues before industry will look to the farm as an industrial raw material source. The problem is so broad that the industry -- both equipment manufacturers and industrial processers -- looks to Government agencies for leadership and coordination of the program. With proper methods and machinery it should be possible to collect along with the main product that part of the agricultural residue suitable for industry and to leave on the soil those parts of use only to the soil. There are indications of feed value in parts of residues. Such values should be studied and methods and equipment developed for collecting such residues to bring further income to the farmer.

Plan of Work: During fiscal year 1941, $2,500 under the appropriation "Industrial Utilization of Farm Products and Byproducts" was utilized to carry out a survey of the present methods and machines used in the collection of agricultural residues and of the possible value of certain residues for industrial uses, food or fertilizer. Inasmuch as these investigations are essentially of an agricultural engineering nature, it is proposed that the plan of work developed as a result of this survey be conducted under this project. Methods of harvesting and collection will be studied. Machines or machine parts adapted to the collection of agricultural residues will be developed and subjected to field tests. The work will be carried on (in cooperation with the Iowa State College) in close collaboration with the Northern Regional Research Laboratory, farmers, industries interested in this line of development, and State agricultural experiment stations. If the Iowa State Agricultural College is in a position to contribute substantially to this work, the former Agricultural Byproducts Laboratory building (Government-owned) at Ames, Iowa (which will no longer be needed for chemical research due to the transfer of such investigations in 1942 to the Northern Regional Research Laboratory), will be used, together with certain experimental equipment already installed to carry on this important work; otherwise, the investigations will be confined to such work as can be carried out in the shops of the Iowa Agricultural Experiment Station. Certain other equipment also belonging to the Bureau and being used in connection with cooperative investigations of the Iowa station on corn production machinery can be drawn upon to help further this residue project.

(c) A decrease of $10,000 due to the dropping of a nonrecurring item provided in 1941 for the construction of a garage and workshop at the Farm Tillage Machinery Laboratory, Auburn, Alabama.

(2) An increase of $10,000 under Project 4, "Mechanical processing of farm products", to expand investigations on the development of more efficient methods and machinery for the processing of fiber flax, as follows:

Objective: To develop tow-cleaning equipment, alter existing flax pullers, design and construct new equipment, develop deseeding machinery, etc., for efficient, high-capacity operations without injury to the fiber.

The Problem and its Significance: On account of climatic conditions, the production of water-retted fiber flax in the United States is at present limited to Oregon. Industry also uses a considerable quantity of dew-retted flax, and Michigan farmers are attempting to produce this type of fiber. The economical production of the crop in both States, however, is handicapped by the fact that the machinery and equipment peculiar to the industry, such as scutchers, pullers, deseeders, etc., are not of a type to produce high-grade fiber at a low cost. At the same time, the industry is too small to interest machinery manufacturers in developing improved harvesting and processing equipment. If the fiber-flax industry in the United States is to expand, the machinery and equipment now in use must be improved or new types developed which will reduce operation costs.

The United States uses a considerable quantity of fiber flax for linen, fish nets, parachute cords, and cordage. Domestic production has never been equal to demand, but it has been possible to supplement our supply by imports. However, the war has greatly reduced our supplies from abroad, and, if war continues, it will be very difficult, if not impossible, to supply our needs. Domestic production of the crop could be increased if the growers could be assured that operation costs of harvesting would be lowered by means of better equipment. The average cost per ton for pulling flax is $4.53. The cost of deseeding approximates $2.29 per ton of deseeded straw. Those figures are out of line with the cost of harvesting small-grain crops. This year a reduction of $2.00 per ton in pulling cost and $1.00 per ton in deseeding would have effected a saving of about $27,000 for the flax industry in Oregon.

Plan of Work: The program as planned for 1942 contemplates (1) continuation of field tests of flax pullers to increase the efficiency of this type of equipment; (2) construction, alteration, and tests of fiber-flax deseeders for increased capacity per unit of labor expended; (3) construction and tests of flax breakers and scutchers to increase the yield of line fiber, with a corresponding decrease in the quantity of tow obtained; (4) development of tow-scutching machinery to clean tow produced in scutching line fiber and to produce commercially acceptable green tow from straw too short to ret and scutch in the usual manner. The plan of work as outlined cannot be efficiently carried out with present funds. The increase requested will provide two additional mechanics and permit the purchase of essential equipment. The work will be carried on in cooperation with flax growers, flax cooperatives, other bureaus of the Department, and the Agricultural Experiment Stations of Oregon and Michigan.

CHANGE IN LANGUAGE

The estimates recommend the following amendment to the language of this paragraph (new matter underscored, deleted matter enclosed with brackets):

> Agricultural engineering investigations: For investigations, experiments, and demonstration involving the application of engineering principles to [agriculture for the investigation, development, experimental demonstration,] agriculture; etc.

The language stricken out, heretofore included in this item as a portion of the authority for dust explosion investigations, is now a superfluous phrase, in view of the fact that the funds and authority for the dust-explosion work were eliminated by Congress in the 1941 Appropriation Act.

WORK UNDER THIS APPROPRIATION

General. The work under this appropriation consists of investigations and reports upon the different kinds of farm power and appliances; farm water supplies and sewage disposal; design, construction, and maintenance of all kinds of farm buildings and related equipment, as well as buildings for processing and storing farm products; farm power and mechanical farm equipment and rural electrification; engineering problems relating to the processing, transportation, and storage of perishable and other agricultural products; and engineering problems involved in adapting physical characteristics of farm land to the use of modern farm machinery; for investigations of cotton ginning and fiber flax; giving advice and assistance in agricultural and chemical engineering; collecting, reporting, and illustrating the results of investigations and preparing, publishing, and distributing bulletins, building plans, and other farm engineering information.

Project 1. Advice and Assistance:

Objective: To prepare and disseminate information on the results of agricultural-engineering investigations with respect to farm structures, farm machinery, farm power, cotton ginning, fiber flax, and rural electrification.

The Problem and its Significance: Information based on research and investigation regarding the more effective use of engineering methods and equipment is prepared in simple form to aid farmers in adjusting their operations to meet changing conditions, to reduce costs, and to more effectively utilize the resources of farm and family.

Plan and Progress of Work: This project covers the preparation of Farmers' Bulletins, Leaflets, Circulars, and other Miscellaneous Publications; preparation and sending out of plans and drawings of farm structures; handling of correspondence; and other activities involved in making available to the public information regarding agricultural engineering work. On request, engineering services on a reimbursable basis are rendered to other bureaus of the Department with respect

to the facilities and equipment required in their work. During the past year more than 350 scientific articles were edited for publication; approximately 50 mimeographed circulars, 25 Department bulletins, and many special addresses and radio talks made by the Chief of the Bureau were prepared. In the Division of Plans and Service, which operates on a reimbursable basis, plans and specifications were prepared for 89 Departmental construction or equipment projects which are estimated to cost when completed around $3,000,000.

Project 2. Farm Mechanical Equipment:

Objective: To improve existing farm mechanical equipment, develop new farm machinery, and determine the basic principles governing efficient performance of such machinery and equipment.

The Problem and its Significance: The damage caused to crops by insect pests and plant diseases is estimated at nearly 2 billion dollars annually. Orchardists and truck farmers must be particularly alert to prevent the destruction of or injury to the quality of their products by insects or disease. The following amounts of the most commonly used insecticides and fungicides were used in 1936-1937:

Lead arsenate	44,000,000 lbs.	Pyrethrum (crude)	11,756,979 lbs.
Calcium arsenate	45,000,000 "	Derris	510,337 "
Sulphur dust	30,000,000 "	Cube	1,829,056 "
Copper sulfate	12,000,000 "	Nicotine sulfate	2,000,000 "

The continual improvement, of insecticide and fungicide dusts, together with the fact that they can be applied more readily and cheaply than in liquid form, is advantageous to their use. Inability to obtain a uniform coating of material which will adhere to the fruit foliage limits their use as dust. While there have been many changes in equipment for applying these materials as spray or dust, experience has shown that satisfactory coverage of plants is frequently not possible with present equipment. Both spraying and dusting machines need to be improved, and more information is essential on the basic principles governing the performance of such equipment before more efficient machines can be developed. These studies should include equipment ranging in size from hand guns to the large power dusters and sprayers.

In 1938 the United States used 7,504,064 tons of fertilizer, representing a cost to the farmers of approximately $200,000,000. Research on methods of fertilizer application to June 30, 1940, covered only about one-third of the commercially important crops in a few selected production areas. The amount of early injury to the crop and the effectiveness of the fertilizer in increasing yields and improving the quality of the crop depend greatly on the method of application, particularly the placement with respect to the seed, plant, or tree. The most effective methods and advantageous types of fertilizer distributing equipment are yet to be determined.

Approximately 500 different kinds of fertilizer distributors, both machines and attachments, employing various mechanical principles and many designs, are now built by more than 100 manufacturers. The number of distributing units on farms is estimated at more than 5,000,000. The designs of fertilizer-dispensing mechanisms differ greatly with respect to uniformity of fertilizer distribution, accuracy of obtaining and maintaining delivery rates, efficiency in handling fertilizers in the various physical forms and amounts required, and because of the effects of other variable conditions on the metering of the fertilizer. Fertilizers cause excessive corrosion of metal parts which shortens the life of the machine and interferes with its operation. It is essential to determine which of the alloys, coatings, or treatments give adequate protection without unduly increasing the cost of the machine.

Extravagant claims based on theoretical considerations are made for many fertilizer placement devices recently placed on the market. When used by farmers many of these machines do not fully meet the claims made for them and there is need to test a representative group of these machines and determine how these difficulties may be corrected.

It is recognized that at least with some crops there exists an optimum relationship between soil tillage, yield, and quality of crops. Inasmuch as many as many accepted field practices, for example in cotton growing, actually increase the cost of production as well as reduce the yield, it is of special importance to the farmer that the proper relationship be determined and the information made available to him. With this crop, investigations already carried out in a comparative study of thirty-seven methods of seed bed preparation on one soil type, have revealed the yield per acre of seed cotton to vary from 351 to 993 pounds per acre and the farmer's income per acre from a net loss of $10.04 to a net profit of $7.43. It seems reasonable to expect similar relationships on other soil types and with other crops.

Plan and Progress of Work:

Work at present is conducted along the following lines:

(a) Pest and plant disease control machinery: Machines and tools will be studied in the laboratory with the idea of devising new or improving existing equipment. Accurate data will be taken on dusting and spraying equipment in order to determine their ability to deliver dusts and sprays accurately and uniformly. The operation of grasshopper poison-bait mixers and spreaders designed herewith will be followed with the idea of improving their usefulness. Further studies will be made of plows and plow attachments in order that better trash and cornstalk coverage may be secured as a means of better controlling the European corn borer.

In the operation of a forced-draft burner for fumigating mushroom houses it was found that in the burning of 2.85 pounds of sulphur per 1,000 cu. ft. of house volume gas concentrations were produced

that were above what is believed necessary to effect complete destruction of mites and insects found in mushroom houses. A grasshopper poison-bait distributor, developed in cooperation with the Bureau of Entomology and Plant Quarantine, over 1,000 units of which were used in 1940, was found capable of spreading at a uniform rate of delivery the desired application of from 15 to 20 pounds of bait per acre, and when operating at the recommended speed of 10 miles per hour had an effective coverage of about 50 acres per hour. One of the outstanding accomplishments was the development of a poison-bait mixer for grasshopper control with which a six-man crew working at a steady economical mixing speed can sack up 10 tons per hour of mixed bait.

Studies of the delivery characteristics of the nozzles of dusting machinery show that the dust is seldom uniformly delivered. As uniform distribution of insecticide dusts is so essential for effective and economical control of insects, the results of these studies should point the way to improvement. In coverage studies for borer control a new type trash guide plow attachment, to prevent "bouncing" when in use, was developed; and the self-aligning disc-joint plow attachment, was redesigned and strengthened to minimize breakage of shanks and spindles.

(b) Fertilizer distributing machinery: Experiments are conducted on fields or plots where different placements, quantities,and kinds of fertilizer are applied to crops and the results of stand and yield compared. Improved methods of fertilizer placement for certain crops, recently determined by the Bureau of Agricultural Chemistry and Engineering, the Bureau of Plant Industry, and several of the State cooperators in the work, make it possible with the same amount of fertilizer that was formerly used, to reduce crop injury and increase yields. The advantage of the improved method compared to inferior methods ranged from 20 to 35 bushels of potatoes per acre in several Eastern States, and from 40 to 109 pounds of tobaccoo or values of $3.00 to $41 per acre, in the Southeastern States, and was equally as striking in other cases. It is reasonable to presume that similar advantages would be realized for crops and conditions not yet studied.

(c) Planting, tillage, and harvesting machinery: In these investigations a variety of selected implements and machines are used to prepare the seedbed and plant, cultivate, and harvest the particular crop. The effectiveness of each machine in performing its function is noted, and these observations are later reflected, in stand, weed control, yield, and quality of crop. Labor and power requirements are also recorded. Based from this information, such alterations in the design and use of the equipment is made as will tend to reduce the cost of producing and harvesting the crop.

Investigations on sugar-beet production machinery are centered in Colorado and California where the main effort is directed toward levelling out the two labor peaks caused by present methods of blocking and thinning, and harvesting. Two types of single seed-ball sugar-beet planters (chain and disc) were developed to improve the uniformity of seed distribution and thereby produce more uniform stands. Thinning as

device has been developed which reduces shelled-corn loss to about one-eighth of the loss with conventional rollers. An apparently satisfactory technique for cultivating drill-planted corn has been worked out. With the extended practice of contour farming in connection with soil conservation, where check-row planting is impracticable, such a development will be extremely helpful. Drill planting of corn might even become general in the corn belt. Time studies of seedbed preparation, planting, and cultivating of corn with tractors of different sizes show that the total labor in these operations with a 16-25 horsepower tractor was 2.74 man hours per acre, while with a 10-14 horsepower tractor they were 5.60 man hours per acre.

Studies of the power, labor, and machinery requirements with respect to the ensiling of forage crops other than corn are under way in New Jersey. Studies of three commercial machines were made and compared with conventional methods of harvesting grass. These machines were designed to take the place of the mowing machine, the grass loader, and the cutting unit of the ensilage cutter. In anticipation of this development, the Bureau has been working on a means of conveying the chopped grass from wagon or truck into the silo. The present method of ensiling entails both chopping and elevating by blowing the material, in which process some 10 or 20 horsepower is used. A 30-foot experimental elevator with a two-horsepower motor was built and operated in 1940 with a fair degree of success. Observations were made and data collected at the New Jersey State Research Farm and elsewhere on different methods and equipment used in producing grass silage. By the end of the 1940 season it is expected to have sufficient material for a cooperative publication.

Project 3. Farm Structures and Related Investigations:

Objective: To develop, through application of research methods, more satisfactory farmhouses, animal shelters, product storages, and other farm buildings and related facilities, and to assist farmers in securing the most suitable and economic structures and equipment when they build or remodel.

The Problem and its Significance: The Farm Housing Survey made by the Department in 1934 indicated that about 210,000 farmhouses in the North, 395,000 in the South, and 95,000 in the West, or a total of about 700,000 farmhouses, had deteriorated to the point where they should be replaced by new buildings. Estimates based on statements of occupants of houses other than those needing complete replacement showed that additional bedrooms were needed in 1,150,000 houses, bathrooms in 1,300,000, living rooms in 530,000, dining rooms in 670,000, and basements under 340,000. The cost of repairing houses not to be replaced was estimated at about $3,250,000,000 if all materials were purchased and all labor hired, with additional large sums needed for additions and modernizing. Many barns, storages, and other farm buildings have depreciated until they are now of little further service, and, in addition, the expansion in livestock and the ever-normal granary are creating needs for more buildings. The number of farms estimated from the reports

of the survey as needing new buildings other than houses was 2,170,000 and the average ground area of new buildings needed per farm was 783 square feet. Repairs to buildings other than houses were found to be needed on 43 percent of all farms. Recent detailed surveys of small sections show that little progress in farm building and equipment rehabilitation has been made since the general survey of 1934. Thus, there is a large accumulated volume of building, repair, and improved equipment to be supplied. As these improvements require large aggregate expenditures by farmers it is important that reliable information about them be made available.

Plan and Progress of Work:

Work at present is conducted along the following lines:

(a) Farmhouses: Studies of the effect of arrangement, materials, and types of construction and equipment upon usefulness, comfort, and convenience are being made in farmhouses occupied by their owners. Similar studies are being made in unoccupied experimental houses to determine the effects of these factors upon fuel consumption and temperature. These investigations are in cooperation with the experiment stations of Wisconsin and Georgia.

These tests have not supported the common opinion that high ceilings are conducive to increased summer comfort in the south. The relative effectiveness of various measures for reducing heat loss from a house in winter has been evaluated. Cottonseed hulls have been found to be satisfactory and relatively inexpensive for use as insulation. Frequently it is not economical to install an improved heating system in a house until the house itself is improved. Findings such as these are included in two technical bulletins being prepared and will contribute substantially to the solution of the farmer's problem of economical and effective housing. The work in occupied farmhouses has also resulted in a number of well-planned examples of remodeling, which are serving as demonstrations to stimulate home improvement and as guides to farmers who are contemplating similar construction.

(b) Buildings for livestock: Plans for buildings for animals are worked out to meet requirements for shelter, ventilation, and convenient handling. Requirements for lighting in dairy barns have been given special attention. A bulletin on farm fencing was issued this year.

(c) Buildings for farm products: Potato storage problems are studied in farm storage houses in cooperation with the experiment stations of Michigan, North Dakota, and Nebraska. As a result, improved construction and storage practices have been developed. Many new storages being built by farmers are utilizing these methods to reduce shrinkage of the potatoes and at the same time prevent damage to the buildings. Studies of pressures developed by various silage materials including the increasingly popular grass silages, are made in silos of the New Jersey Experiment Station and of the

Bureau of Dairy Industry. They indicate that if the design data resulting from these tests are followed costly failures such as have recently occurred can be avoided. Experiments in storage of ear and shelled corn are progressing in cooperation with the experiment stations of Illinois and Iowa.

(d) Equipment and facilities for farm buildings: Studies of heating equipment for both household and farm use which include development of oil burning orchard heaters are in progress. Work on orchard heaters to reduce the smoke nuisance is in cooperation with Johns Hopkins University and the California Experiment Station. A new type of heater and several modifications of types in common use are ready for orchard tests in California this winter. A manuscript for a new bulletin on fireplaces and chimneys has been submitted for publication. Tests of forced-air heating systems are made in connection with the farmhouse studies. This Bureau cooperated informally with the Bureau of Standards and others in revising and simplifying plumbing requirements for low-cost houses.

(e) Transportation of perishable products: Studies of problems in transportation of fruits and vegetables are conducted in cooperation with the Bureau of Plant Industry. With the informal cooperation of railroads and shippers, improved methods of handling, loading, refrigerating, and heating fruits and vegetables under shipment are tested for their effects on the quality of the products. The design of cars and shipping practices now in use are in many respects based on studies by the Department of Agriculture.

(f) Regional plan exchange service: In order to make generally available to farmers results of research work dealing with farm structures, regional plan exchange services have been developed by the State agricultural colleges under the leadership of this Bureau. Catalogs of farm-building plans selected for special merit have been prepared for each of the three regions - Northeastern, Western, and Southern. The Middle West is already served by the Midwest plan service inaugurated in 1933 by the member States. Plans illustrated in these catalogs are made available to farmers through the extension services of the cooperating colleges.

Project 4. Mechanical Processing of Farm Products:

Objective: To develop machinery and equipment for the processing of farm products in order that returns to the farmer may be increased by improving and preserving the quality of the product, developing new or increased uses, and reducing costs of harvesting and processing. The investigations in progress deal with the ginning of cotton and the harvesting and processing of fiber flax.

The Problem and its Significance:

(a) Cotton ginning machinery investigations: Studies on cotton ginning, conducted in cooperation with the Agricultural Marketing Service, are designed to improve the equipment and methods used in harvesting,

ginning, and packaging in order to enhance the quality of the lint, and thus increase the returns to the growers. Research on cotton is justified by its importance in the livelihood of a large part of our population, since it is the principal cash crop of the cotton-producing area. The crop is also of primary importance in domestic commerce and manufacture, the normal domestic use being approximately six million bales. Cotton is also the country's principal agricultural export product. In view of the aggressive competition from high-quality foreign production, the improving of the quality of ginned American cotton is of vital importance to the industry if our export market is to be maintained.

(b) Fiber flax machinery investigations: Work on fiber flax is concerned with the improvement of methods and machinery used in producing high-quality fiber comparable to that produced abroad and, at the same time, to reduce costs of production to the point where American-grown flax can compete with the product of other countries. Some 7,500 acres of fiber flax was grown this year (1940) in the Willamette Valley of Oregon and a few acres in Michigan. Until this year machinery peculiar to the flax industry was manufactured only in Europe, and much of it has not been developed to a point comparable with farm machinery used on other crops. This year (1940) the manufacture of flax machinery in Canada was begun. Linen thread made from fiber flax is used in making webbing for parachutes and in the manufacture of gill and other nets, fire hose, and thread for various purposes. It is essential that our production be kept sufficiently high to supply our most pressing needs in the event that war should completely cut off our supply from abroad. A reduction in the cost of harvesting and processing of fiber flax will tend to increase the domestic production of a nonsurplus crop and to stimulate the development of an industry capable of employing a considerable number of people. Interest in such a development has been aroused as a result of the demonstration of certain pieces of experimental equipment developed by the Bureau which may prove superior to present machinery and also the increase in the market value of flax fiber caused by the war in Europe.

Plan and Progress of Work:

(a) Cotton ginning machinery investigations: An engineering and technological survey of methods, processes, and equipment is being made in each distinctive region of the cotton belt to obtain technical data on machinery set-ups, operating practices, power consumption, and related factors. This information enables the Department to appraise regional ginning conditions and needs; to base its ginning research program upon the most important elements promising greatest returns to cotton farmers; and to evaluate and confirm the practical field or commercial results of improvements adopted by ginners from the research developments of the Laboratory.

Increased capacity and better performance of existing cotton gin equipment are being investigated to increase quality ginning at lower costs to the grower. Laboratory findings on gin saws are being translated at public gins into increased saw speeds to obtain up to

20 percent faster ginning and up to 15 pounds more of useful fiber per bale, as well as better quality throughout. The program also includes investigations of gin roll box shapes, sizes, and positions and saw spacing and sharpening effects.

Research in cleaning aimed toward freeing the ginned fiber of all foreign matter before packaging is now under way. Motes, leaf particles, and pin and pepper trash are now matted into the fiber under pressure when the cotton is baled and must be cleaned out at the spinning mills. Discovery of a practical method to enable gins to bale out pure fiber should enhance the return to the grower.

Some promising applications in cotton quality improvement of roughly harvested and mechanically picked cottons have already arisen from this research. Significant grade improvements have been found by reginning the ginned fiber from mechanical pickers to remove trash and leaf particles. At present the quality gains exceed the cost by only a small margin. It is believed, however, that capacity increases in the process of reginning may be found whereby the operation will become distinctly profitable to the grower.

Packaging and pressing of the ginned lint into bales of uniform weight and quality are urgent needs of the cotton industry today. Research has been undertaken on mechanical sampling of bales during ginning to avoid cutting the bale covering. Processes must be developed for obtaining uniformity, both as to quality and even distribution in all parts of the bale as in compressing bales after ginning, difficulties and possible damaging effects are found especially when bales are one-sided, big-ended, or over-weight.

(b) Fiber flax machinery investigations: A flax puller (harvester) of the type used in Europe has proved adaptable to Oregon conditions. With certain alterations the machine will apparently give better service than pullers previously used. Deseeding, threshing, and seed cleaning have been combined into a single operation by the development of a new type of deseeder. This experimental deseeder has a greater capacity per unit of man labor and leaves the flax straw in better condition for subsequent operations than the equipment displaced. About 1,200 tons of flax straw from the 1939 crop have been deseeded at one of the farm cooperative plants with the experimental unit. A tow shaker developed under this project has proved to be a valuable piece of equipment for the tow-cleaning operation. It is planned to continue field tests of flax pullers and to design, construct, and test deseeders, flax breakers, and scutchers.

Project 6. Rural Electrification Investigations:

Objective: (1) to conduct investigations leading to the development of uses for electricity which will increase cash income, or produce goods for home consumption from materials available on the farm, or effect savings over the cost of facilities replaced, in addition to raising the standard of farm living conditions; (2) to undertake fundamental

studies on the effect of light in the control of bacteria and insect pests, as well as a study of the lighting of farm buildings and other similar studies in the use of radiated energy.

The Problem and its Significance: The widespread growth of rural electrification has taken electricity to all classes of farms. The majority of electricity used on the farm is in the home, where, while it is a factor in improving farm living conditions, it contributes but little toward its own cost. The problem is: What income-producing uses can be developed on the farm outside the home that will support the entire electrification program and perhaps net an income in addition. The Government has invested in rural electrification about $341,000,000, as of November 30, 1940, as compared with an investment of approximately one billion dollars by the farmers and power companies, making a total estimated investment of 1-1/3 billion dollars. Much of the money involved is borrowed and cannot be repaid from earning from the use of electricity unless more income-producing uses are adopted, discovered, or developed. Research in the profitable uses of electricity on the farm has been limited largely to those farms most able to support electrification, yet even on those farms paying uses have not been developed adequately. Until the past four or five years, rural lines have, for a major part, been built to this class of farm. Research on problems in equipment for the low income farm must be emphasized in the future if these farms are to be benefitted by electricity.

The control of bacteria in the dairy is a problem which calls for extreme vigilance on the part of every producer. Any satisfactory method of treating dairy utensils must be economical and as nearly automatic as possible. The lighting of farm buildings other than the home has been mostly hit and miss. Investigations in the actual light requirements for safety of the worker, for maintaining sanitary conditions, and for its effect upon animals are needed if the most effective and efficient use is to be obtained.

Plan and Progress of Work: In planning a program of investigations of the uses of electrical energy for income-producing purposes, emphasis has been placed primarily on problems of greatest importance to low-income farms. It is recognized that income-producing applications must be discovered or developed and adopted by these farms if electricity is to be used to their economic advantage. Activities under this project have been as follows: A survey was made by the Bureau to determine the extent of rural electrification research, both active and completed, applicable to the dairy and poultry industries. The results of the surveys, which included 37 States, have been analyzed and used as a basis for planning the rural electrification research program of the Bureau. The investigations are conducted in cooperation with the agricultural experiment stations of Indiana, Nebraska, Virginia, and the University of Georgia. Among the electrification problems being studied are the development of economical methods of cooling eggs on farms, the warming of drinking water for livestock during cold weather, the grinding of ear corn with small mills, and the electric brooding of chicks out of doors. Tests will be made with energy in the

ultra-violet band to determine if economically satisfactory sterilization of dairy utensils can be accomplished with it. Results of studies in dairy barns suggest the possibility of improving the quality of stable lighting without increasing the cost--even reducing it in some cases. Complete results have not yet been obtained on any of these problems. One study of the use of electrically heated hovers for small pigs showed that 79 percent of the pigs farrowed alive were saved where the heated hover was used, as compared with 49 percent where it was not used, and that the pigs which had the heated hover gained 0.318 of a pound per day, as compared with 0.259 of a pound gained by the pigs in pens where the warmed hover was not used.

Analyses will be made of low-income farm operations and processes to determine the practicability of using electricity economically as a source of power. Present studies on the Irwinville, Ga., and LaForge, Mo., resettlement projects of the Farm Security Administration will be continued.

(e) NAVAL STORES INVESTIGATIONS

Appropriation Act, 1941	$93,400
Budget Estimate, 1942	92,400
Decrease	1,000

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)	Decrease
Naval Stores Investigations:				
(a) Investigation of naval stores production, processes and equipment.....	$41,651	$39,906	$39,906	- -
(b) Investigation of the composition, properties, components, and derivatives of naval stores...	25,344	26,241	26,241	- -
(c) Investigation of uses handling, and transportation of naval stores....	21,591	23,253	23,253	- -
(d) Repairs and alterations at the Naval Stores Station, Olustee, Florida	- -	4,000	3,000	- $1,000 (1)
Unobligated balance.....	814	- -	- -	- -
Total.....	89,400	93,400	92,400	- 1,000

DECREASE

(1) The decrease of $1,000 in this item for 1942 consists of:

(a) An increase of $3,000 to repair the roads and ditches and extend the drainage system at the Naval Stores Station, Olustee, Florida. This is a non-recurring item.

Objective: To make needed repairs to roads and drainage ditches on the grounds of the Naval Stores Station, Olustee, Florida.

The Problem and its Significance: The Naval Stores Station, representing an investment of over $150,000, is located on a ten-acre tract one mile from Olustee, Florida, and includes twenty-one structures.

The roads on the Station grounds were constructed without the use of any road binder or building material and, because of the composition of the soil, they will not withstand the heavy usage to which they are put and are now greatly in need of repair.

Certain operations at the plant laboratory necessitate the disposal of large quantities of water and waste liquids. The very flat terrain makes proper drainage difficult, especially after an unusually heavy rain. The present drainage system requires repair and extension, in order to meet minimum drainage requirements and to adequately protect the health of the laboratory personnel.

The Bureau has received so many requests from the gum naval-stores industries for information on the entire scope of handling and processing naval stores that it has been impossible to set aside any funds from the regular Naval Stores appropriation for the maintenance of the station property beyond minor and miscellaneous repairs to equipment and buildings. A similar condition exists regarding the roads and surface drainage system. In order to effect these general repairs, an increase of $7,000 was submitted in the budget estimates for 1941 to "provide material and labor to repaint the frame buildings at the Naval Stores station, Olustee, Florida, in order to protect and preserve them, and to repair old roads and drains on the station grounds." Of this amount, $4,000 was appropriated for 1941 to be used to repaint the 21 structures at the station. There still remains, however, the problem of repairing the roads and repairing and extending the drainage system.

Plan of Work: These repairs will be accomplished either by force account or by contract in accordance with existing regulations. The $4,000 appropriated for 1941 has been utlized to repaint the 21 structures at the Naval Stores station. As a result, the general appearance of the station has been greatly improved and the life and usefullness of the buildings prolonged.

(b) A decrease of $4,000 due to the dropping of a nonrecurring item provided in 1941 for repainting all frame buildings at the Naval Stores station, Olustee, Florida.

WORK UNDER THIS APPROPRIATION

Objective: To develop improved methods and equipment for the production of turpentine and rosin in order to make available products more nearly meeting the physical and chemical requirements of the consuming industries; to determine the chemical composition of pine oleoresin (pine tree gum) and the various turpentines and rosins in order to produce derivatives which may prove of industrial value; to develop methods of handling, packaging, and storing naval stores which will minimize deterioration.

The Problem and its Significance: Of the 50,000,000 acres of pine forested lands in the South, approximately 35,000,000 are used for the production of naval stores. The standard of living of nearly 400,000 people in the naval-stores belt, which extends from North Carolina through South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and eastern Texas, is dependent upon a prosperous naval-stores industry. Of this number at least 20,000 gum farmers look upon pine tree gum as their day-to-day cash crop. This income is threatened because of the fact that exports which formerly consumed 55 percent of production have dropped to 40 percent, and there is reason to believe that in the future exports will not increase. The result is an accumulation of stocks of turpentine and rosin which is in excess of domestic consumptive demand. In addition, the natural regrowth of Southern yellow pine will bring on the market in the near future considerably more turpentine than is now produced, for which uses must be found. In fact, a survey by the U. S. Forest Service indicates a potential annual increase of 300,000 units (a unit equals 1 barrel of turpentine and 3-1/3 barrels of rosin) of gum naval stores and 75,000 units of wood naval stores from trees already growing. In view of these facts, there is need of research effort to find outlets for turpentine and rosin and their derivatives as commercially valuable commodities. The successful outcome of such research effort, resulting in a greatly increased demand for naval-stores products, would undoubtedly be of considerable assistance in land-use adjustment in the South where a vast area of submarginal land is used to raise agricultural crops for which there is no demand at present.

Plan and Progress of Work: Designs for turpentine fire still sheds and settings and improved technique of distillation have been made available to naval-stores producers. The possible use of oil as a fuel to replace wood in the direct fire turpentine still will be investigated. A method of gum cleaning has been developed and the first private commercial plant using the process has started operation. Modifications in the batch process will be studied. Work now under way in the laboratory on the development of a continuous gum cleaning plant will be translated to a larger scale operation. The small continuous steam still already designed will be tested with the continuous cleaning system and translated to a large scale.

The practical woods test of the various classes of turpentine cups will be continued, with special attention to the glass cups recently developed by the Naval Stores Division.

The turpentine separator and dehydrator already developed under this project has been adopted rapidly by the industry. Studies to add deacidification as another step in turpentine conditioning will be continued and necessary technique and equipment developed. This information will be extended to use where turpentine is stored in large steel storage tanks.

The introduction by cooperative agents in Georgia and Florida (the leading naval-stores producing States) of improved technique and equipment developed by these studies will be continued. It is planned to extend this service to Alabama.

With the study of the composition of turpentine well under way, investigations on the production of derivatives of these components by such means as pyrolysis and oxidation will be undertaken. Several articles have already been issued relating to the composition of the pine oleoresin and of the rosin and turpentine. This work will be continued with particular stress on a study of the structure of the various compounds, with the view of producing through isomerization or chemical reaction derivatives with potential industrial value.

That rosin serves a valuable purpose in soap and is not a "filler" as generally claimed has been determined by the studies in progress. This investigation includes soaps made from modified rosins and resin and rosin acids. This work will be continued. The data from the soap studies will serve also as a basis for an investigation of rosin sizes on paper and paper products.

Encouraged by results already obtained in the study of rosin as a plant growth stimulant, work is being started to observe the effect of finely divided rosin on the soil flora in sterilized and unsterilized soils. Studies on the application of resinates as a sticker for commercial fungicides and current experiments on the use of resinates in the treatment of mulch fabrics will be continued. The value of modified turpentine as paint vehicles will be investigated.

Semi-annual naval stores reports on production, stocks, and consumption of turpentine and rosin will be issued as of September 30 and March 31.

SUPPLEMENTAL FUNDS

(Complete bureau statement)

Direct Allotments

Projects	Obligated, 1940	Estimated obligations, 1941	Estimated obligations, 1942
Arbitration of Smelter-Fumes Controversy, United States and Canada (Transfer from State Dept. to Agriculture): For smelter-fumes investigations to determine damage to crops and forests in the State of Washington	$8,989	- -	- -
Special Research Fund: For special research projects in the fields of chemistry and engineering	248,086	$230,110	$200,910
Conservation and Use of Agricultural Land Resources (New Uses and Markets for Farm Commodities, Regional Laboratories): For four regional research laboratories, to develop new uses and markets for farm commodities, authorized by Sec. 202 of the Agricultural Adjustment Act of 1938	3,120,732	2,979,000	3,976,000
Total, Supplemental Funds, direct allotments	3,377,807	3,209,110	4,176,910

PASSENGER-CARRYING VEHICLES

The authorization for the purchase of passenger-carrying vehicles for the Bureau of Agricultural Chemistry and Engineering contemplates a decrease of $1,325 ($3,725 in 1941, $2,400 estimated for 1942) for this purpose. This $2,400 will permit the needed replacement of four vehicles at a net average cost of $600 when exchange allowances are taken into account.

The automobile is indispensable for the proper conduct of the Bureau's work, since a great many of the points visited are in remote areas where public transportation facilities are very limited and in many cases not available. The Bureau has many experimental projects located on privately-owned farms, and it is sometimes necessary that employees go from farm to farm in checking up on these projects. Public conveyances are not

available for such trips, but an automobile makes it possible to visit a number of farms in a day. The purchase and operation of Government-owned cars has been found from experience to be more economical than either the hiring of commercial automobiles or the use of personally-owned cars of employees on a mileage basis. Records kept over a series of years indicate that the average per-mile cost of a Government-owned car, figuring in the purchase price and all operating and maintenance expenses up to the time it is turned in as no longer serviceable and then deducting the exchange allowance, is less than 3 cents. On the other hand, the cost of hiring personally-owned vehicles averages about 4 cents per mile and for hiring commercial cars from 10 to 15 cents per mile.

None of the cars to be replaced are of a model more recent than 1938. These machines have been operated under practically all conditions of use, ranging from city streets to extremely rough country roads. Their average performance as of June 30, 1940, was approximately 35,000 miles, and it is estimated that their average mileage will be approximately 50,000 miles before they are actually turned in. In the experience of the Bureau, cars will not operate efficiently or economically beyond this mileage, and it appears to be distinctly in the best interests of the work to turn them in during the fiscal year 1942, as herein provided.

CONSERVATION AND USE OF AGRICULTURAL LAND RESOURCES, DEPARTMENT OF AGRICULTURE

NEW USES AND MARKETS FOR FARM COMMODITIES, REGIONAL LABORATORIES

Appropriation Act, 1941$3,000,000 (a)
Budget Estimate, 1942 4,000,000 (a)
Increase$1,000,000

(a) Allotment pursuant to Sec. 202(a) - (e) A. A. Act of 1938 (52 Stat. 31-70) from "Conservation and Use of Agricultural Land Resources, Department of Agriculture", provided by Agricultural Appropriation Act.

PROJECT STATEMENT

Projects	1940	1941 (estimated)	1942 (estimated)	Increase or decrease
1. Northern Regional Research Laboratory, Peoria, Ill.:				
(a) Initial admin.	$81,720	- -	- -	- -
(b) Acquisition of site and construction and equipment of bldg.	611,300	$195,000	$118,500	- $76,500
(c) Agricultural residues utilization inves.	- -	150,000	250,000	+ 100,000
(d) Corn utiliz. inves.	- -	286,450	472,250	+ 185,800
(e) Wheat utiliz. inves. ...	- -	63,500*	120,000*	+ 56,500
(f) Tech. features of const. and design	8,883	8,000	- -	- 8,000
(g) Plans and spec. and supervision of const.	50,536	14,300	- -	- 14,300
Total, Northern Laboratory ...	752,439	717,250	960,750	+ 243,500 (1)
2. Southern Regional Research Laboratory, New Orleans, La.:				
(a) Initial admin.	80,152	- -	- -	- -
(b) Acquisition of site and construction and equipment of bldg.	633,000	170,590	94,500	- 76,090
(c) Cotton utiliz. inves. ..	- -	431,728	693,000	+ 261,272
(d) Sweetpotato utiliz. inves.	- -	58,052	121,275	+ 63,223
(e) Peanut utiliz. inves. ..	- -	24,880	51,975	+ 27,095
(f) Tech. features of const. and design	8,234	8,000	- -	- 8,000
(g) Plans and spec. and supervision of const.	48,610	24,000	- -	- 24,000
Total Southern Laboratory	769,996	717,250	960,750	+ 243,500 (1)

PROJECT STATEMENT - Continued

Projects	1940	1941 (estimated)	1942 (estimated)	Increase or decrease
3. Eastern Regional Research Laboratory, Wyndmoor, Pa.:				
(a) Initial administration	$ 84,165	$ - -	$ - -	- -
(b) Acquisition of site and construction and equipment of building	628,500	209,000	160,000	- 49,000
(c) Apple utiliz. inves. .	- -	43,500*	72,700*	+ 29,200
(d) Vegetable crop utiliz. inves.	- -	18,000*	29,000*	+ 11,000
(e) Tobacco utiliz. inves.	- -	90,000	148,000	+ 58,000
(f) Milk products utiliz. investigations	- -	135,000	223,000	+ 88,000
(g) Animal fats and oils utiliz. inves.	- -	95,000	156,400	+ 61,400
(h) Potato utiliz. inves.	- -	68,450*	113,650*	+ 45,200
(i) Tanning materials, hides, skins, and leather utiliz. inves.	- -	36,000	58,000	+ 22,000
(j) Tech. features of const. and design	7,528	8,000	- -	- 8,000
(k) Plans and spec. and supervision of const. ..	48,563	14,300	- -	- 14,300
Total, Eastern Laboratory ..	768,756	717,250	960,750	+243,500 (1)
4. Western Regional Research Laboratory, Albany, Calif.:				
(a) Initial administration	84,808	- -	- -	- -
(b) Acquisition of site and construction and equipment of building ..	603,600	170,000	76,000	- 94,000
(c) Apple utiliz. inves. .	- -	29,400*	85,800*	+ 56,400
(d) Alfalfa utiliz. inves..	- -	75,000	137,200	+ 62,200
(e) Fruits utiliz. inves..	- -	165,000	236,250	+ 71,250
(f) Potato utiliz. inves..	- -	22,000*	46,000*	+ 24,000
(g) Poultry utiliz. inves.	- -	91,300	140,600	+ 49,300
(h) Vegetable crop utiliz. inves.	- -	96,000*	158,400*	+ 62,400
(i) Wheat utiliz. inves. .	- -	43,150*	80,500*	+ 37,350
(j) Tech. features of const. and design	7,330	8,000	- -	- 8,000
(k) Plans and spec. and supervision of const. ..	54,190	17,400	- -	- 17,400
Total, Western Laboratory ..	749,928	717,250	960,750	+243,500 (1)
5. Central Administration, Planning and Coordination, Washington, D. C.:	88,265	131,000	157,000	+ 26,000 (1)
Total Appropriation	3,129,384	3,000,000	4,000,000	+1,000,000

*Joint Commodity projects, as follows:

Joint Commodity Projects:

	Northern Lab.	Eastern Lab.	Western Lab.	Total
Wheat utilization investigations:				
1941 Allotment	63,500	- -	43,150	106,650
1942 Estimate	120,000	- -	80,500	200,500
Apple utilization investigations:				
1941 Allotment	- -	43,500	29,400	72,900
1942 Estimate	- -	72,700	46,000	118,700
Vegetable Crop utilization investigations:				
1941 Allotment	- -	18,000	96,000	114,000
1942 Estimate	- -	29,000	158,400	187,400
Potato utilization investigations:				
1941 Allotment	- -	68,450	22,000	90,450
1942 Estimate	- -	113,650	85,800	199,450

The research program for each commodity, with an indication of the problem and its significance and the plan of work, is briefly discussed on the following pages:

Agricultural residues page 59
Corn page 60
Wheat page 62
Cotton page 63
Sweetpotatoes page 69
Peanuts page 70
Apples page 72
Vegetables page 74
Tobacco page 77
Milk products page 79
Animal fats and oils page 80
Potatoes page 81
Tanning materials, hides, skins and leathers page 84
Alfalfa page 86
Fruits page 88
Poultry page 91

INCREASES AND DECREASES

(1) The increase of $1,000,000 in this item for 1942 consists of a net increase of $243,500 for each of the four regional research laboratories and an increase of $26,000 for central administration, planning and coordination, Washington, D. C., restoring the appropriation for this activity to the $4,000,000 authorized under the Agricultural Adjustment Act of 1938.

In 1938 Congress recognized the need for greater industrial outlets for farm crops, particularly the surpluses, and authorized an annual appropriation of $4,000,000 for the establishment and maintenance of four regional research laboratories, one for each of the major agricultural producing areas of the country, to search for new and wider industrial outlets and markets for farm commodities.

In the initial appropriation of $4,000,000 Congress directed that a survey be made (a) to gather information on research already under way on the industrial utilization of agricultural products; (b) to determine the scope of the research to be undertaken in the laboratories; and (c) to assemble data for the location of the laboratories. The survey revealed that there is ample justification for the annual expenditure of $4,000,000 for this research. With this established, the laboratory buildings were designed and constructed to provide the facilities and house the personnel required for a research program of this scope.

The authorization of $4,000,000 a year for these laboratories was reduced by Congress to $3,200,000 in the fiscal year 1940 and to $3,000,000 in 1941 on the basis that the facilities could not be completed in time to permit employment of the personnel provided in the budget estimates.

The buildings have now been completed and facilities will be available during the coming year to accommodate the full personnel contemplated under the $4,000,000 appropriation and required for the most efficient utilization of the facilities. In terms of the scientific worker who will actually find the solution to the many complex research problems on the utilization of farm surpluses, the present reduced appropriation will not provide an adequate organization at each laboratory in view of problems to be solved for each commodity, the proposed program, and the potential returns to both agriculture and industry.

The restoration of the $4,000,000 as provided in the original authorization, will make it possible to increase the staff at each laboratory by approximately 90 employees, or from 212 to 302. 80 of the 90 additional employees will be scientific workers, increasing this group by over 66% or from approximately 120 to 200. Since the productive capacity of a research laboratory of this nature is dependent upon an adequate research staff to cope with the numerous problems, many of which require individual study, the increase of over 66% in this group of employees is extremely significant. The utilization of practically all of the increase for the employment of additional scientific workers is made possible by the fact that the normal operating expenditures of the laboratories, such as building maintenance, heat, water, electricity, maintenance of non-technical personnel, business operations, etc., are relatively fixed and will remain static within wide limits of variation in the number of scientific workers employed.

A national emergency exists in which the utilization of our surplus agricultural commodities for the replacement of strategic and critical raw materials is of the greatest importance to the civil population as well as to the armed forces. The appropriation of the full $4,000,000, originally

authorized for the four regional laboratories, is imperative if the laboratories are to be in a position to cope with this situation to the fullest extent.

WORK UNDER THIS APPROPRIATION

Origin and Brief History of the Four Regional Research Laboratories:

The Department of Agriculture, as well as other branches of the Federal Government, has long been interested in the industrial utilization of agricultural products and important contributions have been made to that end. There has been a growing conviction, however, especially since the beginning of the great depression of 1930, among scientists and economists within the Government service, and also among farmers, industrialists, and scientists outside of the Government organization, that there was much greater need for industrial utilization of agricultural products, particularly for non-food uses, in order to improve the status of agriculture and the economic condition of the country.

In recent years there have been numerous bills introduced into Congress designed to increase further the activities of the Government toward industrial utilization of agricultural products. Several of these related to the production of alcohol from surplus crops for use in motor fuels; others related to the development of more extensive uses for cotton or other regional crops; and some related to the development of uses for agricultural wastes. All of them failed to pass, but the sentiment of many members of Congress finally crystallized in a bill introduced in 1937. This bill was combined, after several revisions, with the one designed to reorganize the Agricultural Adjustment Administration and became law as part of the Agricultural Adjustment Act of 1938. Section 202(a) - (e) of this Act reads as follows:

"(a) The Secretary is hereby authorized and directed to establish, equip, and maintain four regional research laboratories, one in each major farm producing area, and, at such laboratories, to conduct researches into and to develop new scientific, chemical, and technical uses and new and extended markets and outlets for farm commodities and products and byproducts thereof. Such research and development shall be devoted primarily to those farm commodities in which there are regular or seasonal surpluses, and their products and byproducts.

(b) For the purposes of subsection (a), the Secretary is authorized to acquire land and interests therein, and to accept in the name of the United States donations of any property, real or personal, to any laboratory established pursuant to this section, and to utilize voluntary or uncompensated services at such laboratories. Donations to any one of such laboratories shall not be available for use by any other of such laboratores.

(c) In carrying out the purposes of subsection (a), the Secretary is authorized and directed to cooperate with other departments or agencies of the Federal Government, States, State agricultural experiment stations, and other State agencies and institutions, counties, municipalities, business or other organizations, corporations, associations, universities, scientific societies, and individuals, upon such terms and conditions as he may prescribe.

(d) To carry out the purpose of subsection (a), the Secretary is authorized to utilize in each fiscal year, beginning with the fiscal year beginning July 1, 1938, a sum not to exceed $4,000,000 of the funds appropriated pursuant to section 391 of this Act, or section 15 of the Soil Conservation and Domestic Allotment Act, as amended, for such fiscal year. The Secretary shall allocate one-fourth of such sum annually to each of the four laboratories established pursuant to this section.

(e) The Secretary shall make a report to Congress at the beginning of each regular session of the activities of, expenditures by, and donations to the laboratories established pursuant to subsection (a)."

Fiscal Year 1939

The Agricultural Appropriation Act for the fiscal year 1939 provided $4,000,000 under "Conservation and Use of Agricultural Land Resources" for the above purpose, and directed that not to exceed $100,000 should be expended:

"to determine the location of said laboratories and the scope of the investigations to be made and to coordinate the research work now being carried on."

By order of the Secretary of Agriculture, dated October 6, 1938, the administration and operation of the regional research laboratories was placed in the Bureau of Chemistry and Soils (now Bureau of Agricultural Chemistry and Engineering).

Allocations of funds for the fiscal year 1939 were as follows:

	Amount Allocated	Percentage of Total
Surveys	$ 77,420	1.94 %
Central Admin., planning and coordination, Wash., D. C.	46,500	1.16 %
Operation and maintenance of laboratories (Temporary field offices)	100,817	2.52 %
Construction and equipment of laboratory buildings	3,775,263	94.38 %
Total	$4,000,000	100.00 %

(c) In carrying out the purposes of subsection (a), the Secretary is authorized and directed to cooperate with other departments or agencies of the Federal Government, States, State agricultural experiment stations, and other State agencies and institutions, counties, municipalities, business or other organizations, corporations, associations, universities, scientific societies, and individuals, upon such terms and conditions as he may prescribe.

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The survey directed by this appropriation act was completed and a report submitted to Congress. This report was printed as Senate Document No. 65, 76th Congress, 1st Session. During the survey specialists of the Department personally interviewed representatives of 1,300 research institutions, including about 1,100 industrial research laboratories.

On the basis of information collected in this survey, the four farm producing areas were designated and locations chosen for the four laboratory buildings, as shown below:

Northern Area	Southern Area	Eastern Area	Western Area
Illinois	Alabama	Connecticut	Arizona
Indiana	Arkansas	Delaware	California
Iowa	Florida	Kentucky	Colorado
Kansas	Georgia	Maine	Idaho
Michigan	Louisiana	Maryland	Montana
Minnesota	Mississippi	Massachusetts	Nevada
Missouri	Oklahoma	New Hampshire	New Mexico
Nebraska	South Carolina	New Jersey	Oregon
North Dakota	Texas	New York	Utah
Ohio		North Carolina	Washington
South Dakota	(Laboratory located at New Orleans, La.)	Pennsylvania	Wyoming
Wisconsin		Rhode Island	
		Tennessee	(Laboratory located at Albany, Calif., San Francisco Bay area)
(Laboratory located at Peoria, Ill.)		Vermont	
		Virginia	
		West Virginia	
		(Laboratory located at Wyndmoor, Pa., Philadelphia area)	

Sites were acquired and plans and specifications prepared for construction of the buildings.

The general designs and layouts of all four buildings are similar. They are U-shaped structures, three stories and basement, consisting of an administrative unit, chemical laboratory wing with 72 laboratories, and an industrial laboratory wing, with separate powerplant buildings. Laboratory rooms and facilities are provided to serve a staff of approximately 200 professional employees, along with the necessary administrative, clerical, custodial, and mechanical personnel.

The following farm commodities were selected to receive initial attention by the regional laboratories:

Northern Laboratory	Southern Laboratory
Agricultural Residues	Cotton
Corn	Sweetpotatoes
Wheat	Peanuts

Eastern Laboratory	Western Laboratory
Apples	Apples
Vegetables	Alfalfa
Tobacco	Fruits
Milk Products	Potatoes
Animal Fats & Oils	Vegetables
Potatoes	Poultry
Tanning materials, hides, skins & leathers	Wheat

The laboratory directors were appointed in January, 1939 and temporary headquarters established at each location the following month. Several of the keymen were later appointed to assist in planning and developing a well-rounded, coordinated program of research.

In June, 1939 actual construction work started on the administrative unit and chemical laboratory wing of all four buildings.

Fiscal Year 1940

The Agricultural Appropriation Act for the fiscal year 1940 restricted the expenditure for the regional research laboratories to the sum of $3,200,000 in that fiscal year, and interpreted the scope of research work to be carried on in the laboratories as "including research on food products of farm commodities".

Allocations of funds for the fiscal year 1940 were as follows:

	Amount Allocated	Percentage of Total
Central Admin., planning and coordination, Wash., D. C.	$ 105,000	3.28 %
Operation and maintenance of laboratories (Temporary field offices)	365,600	11.43 %
Construction and equipment of laboratory buildings	2,729,400	85.29 %
Total	$3,200,000	100.00 %

Plans and specifications were prepared for standard fixed laboratory equipment to be installed in the chemical laboratory wings and for other special equipment of a fixed nature. Actual construction work on the industrial laboratory wings started in February, 1940; in June laboratory equipment contracts were let to equip 65 of the 288 laboratory rooms provided.

Additions were made to the laboratory staffs at each location during the year. The divisional organizations were tentatively established and most of the division chiefs selected. These employees were engaged during the year in the formulation of the research program which involved establishing contacts with industry, the experiment stations, and educational institutions, and developing the scientific and technical background of the program through exhaustive literature and patent searches, after which

research projects in tentative form were prepared and submitted to Bureaus in the Department for their consideration and comment in order to provide for necessary coordination with present related research. These projects were also submitted to the State Agricultural Experiment Stations for their consideration, after which conferences were held at each of the laboratories to consider the research program in relation to related work now being performed by the State Stations. At these meetings a satisfactory basis was established for the organization of cooperative agricultural and industrial committees to promote the most effective program of research.

By the end of the fiscal year 1940 the total number of persons employed by the laboratories was 96, or approximately 24 employees for each laboratory.

Fiscal Year 1941

The Agricultural Appropriation Act for the fiscal year 1941 further restricted the expenditure for the regional research laboratories to the sum of $3,000,000 in that fiscal year, retaining the proviso interpreting the scope of the research work to be carried on in the laboratories as "including research on food products of farm commodities".

Allocations of funds for the fiscal year 1941 are as follows:

	Amount Allocated	Percentage of Total
Central Admin., planning and coordination, Wash., D. C.	$ 131,000	4.37 %
Operation and maintenance of laboratories	2,022,410	67.41 %
Construction and equipment of laboratory buildings	846,590	28.22 %
Total	$3,000,000	100.00 %

During the early part of the fiscal year 1941 the divisional organization of the laboratories was completed; the selection of qualified research workers has continued; contracts have been awarded for equipping an additional 125 laboratory rooms leaving approximately 98 rooms to be equipped in 1942. Construction of the administrative units and chemical laboratory wings of the Eastern, Western and Northern Laboratories have been completed and possession was taken in August, November, and December, 1940, respectively. It is estimated that these units for the Southern Laboratory will be completed in March, 1941. Standard fixed laboratory equipment is now (Jan. 1941) being installed in the Northern, Eastern, and Western Laboratories. In the meantime a small number of temporary laboratory units have been installed in the Eastern, Western and Northern Laboratories, thus enabling the present staff to commence actual laboratory research. This temporary equipment will find use later in some of the basement rooms in the industrial units. Plans and specifications for special experimental equipment (including large scale pilot plant equipment) and for grading, walks, roadways, etc., are under preparation and contracts will be awarded during this fiscal year. A small amount of miscellaneous construction work will carry over into the fiscal year 1942.

The laboratory staffs at the present time (January 1, 1941) numbers 301 persons, ranging from 44 at the Southern Laboratory to 90 at the Eastern Laboratory. Additional personnel will be appointed during the remainder of the year as equipment and other facilities are made available, and by the end of the fiscal year 1941 it is planned to have approximately 625 employees on the rolls, ranging from 106 at the Southern Laboratory to 180 at the Eastern Laboratory.

Fiscal Year 1942

The budget estimate for the fiscal year 1942 contemplates the restoration of the appropriation for this activity to the original $4,000,000.

Estimated allocations of funds are as follows:

	Amount	Percentage of Total
Central Admin., planning and coordination, Wash., D. C.	$ 157,000	3.92 %
Operation and maintenance of laboratories	3,394,000	84.85 %
Construction and equipment of laboratory buildings	449,000	11.23 %
Total	$4,000,000	100.00 %

During 1942 the remaining laboratory rooms will be equipped and miscellaneous construction work completed. With the restoration of the appropriation to the original $4,000,000, it is planned to increase the personnel to the full laboratory strength of approximately 1,200 employees, or 300 employees for each laboratory, during the 1942 fiscal year.

Research Program of the Four Regional Research Laboratories: The Department of Agriculture, as a result of its scientific and technological research, has never manufactured anything for commercial purposes and it does not expect to in these regional laboratories. It expects to stimulate industries, as it has done frequently in the past, by showing the possibilities of financial profit from the processing of agricultural materials. In order to do this, processes which have been developed successfully in the laboratory will be tried out on a pilot plant scale in order to determine probable costs in commercial practice. Efforts will be concentrated on the development and improvement of processes which will make possible the profitable production of industrial products for which there is a present or potential demand. The research program for each commodity selected, with an indication of the problem and its significance and the plan of work, is briefly discussed in the following:

Objective: To search for and develop new scientific, chemical and technical uses for surplus agricultural residues, corn, wheat, cotton, sweetpotatoes, peanuts, apples, vegetables, tobacco, milk products, animal fats and oils, potatoes, tanning materials, hides, skins, and leathers, alfalfa, fruits, and poultry.

Agricultural Residues Utilization Investigations
(Northern Laboratory)

The Problem and its Significance: Each year in the United States there are 100 to 200 million tons of straw, stalks, hulls, and other crop residues of which little or no use is made. Effective use of these materials is not only neglected, but frequently their presence constitutes a serious nuisance, the elimination of which involves additional expense to the farmer. Inasmuch as the farmer's monetary returns from the sale of his crops in recent years have been far below parity he can ill afford this additional expense; instead this vast amount of raw material should give him a positive return. That he is in great need of additional income is evidenced by the fact that the Government has found it necessary to make substantial parity payments to him. These residues, being composed of lignin, cellulose and hemicelluloses, three chemical components attracting world wide industrial attention today, should, and with proper economic methods of harvesting and collection, can yield to the farmer additional dollar values.

Many uses have been developed for certain of these residues, and but few have survived economic competition, failing either because of deficiencies in quality or generally because of too high cost as raw materials for industry. New methods of pulping, using materials as chemicals, plastics, etc., are constantly presenting themselves, opening continually new lines of attack. Power machinery, changing conditions of farm practice, the necessity of more farm income are all driving forces to make possible practical and economic methods of collection and harvesting. With new lines of attack and such driving forces in agricultural practice certainly an opportunity is at hand for greater farm income.

Neither industry nor the farmer is able to attack this problem in the broad-gauge manner that is needed to produce the desired results -- Government action is necessary.

The development of new materials from agricultural wastes in the event of a national emergency, offers many possibilities. The production of cellulose to supplement the dwindling supplies of wood pulp for chemical industries and for paper, the possibility of the production of cheap plastics along lines already explored, the development of substitutes for cork, kapok, and activated carbon, and the production of synthetic rubber from furfural derived from these residues, offer real possibilities.

Plan of Work: New and increased industrial utilization of agricultural residues must depend on the development of more economical methods of collection and processing as well as new uses for residues. An extensive research program will be continued along the following lines:

(1) Economic and practical methods of storage and maintenance in uniform condition of agricultural residues.

(2) Methods of utilizing these residues as pulps for paper, chemical industry, etc.

(3) Investigation of the chemical and physical constitution of lignin and its industrial utilization.

(4) Investigation of the chemical and physical constitution of hemicelluloses and their derivatives and their industrial utilization.

(5) Uses of residues in manufacturing building materials, plastics for building, aeroplane, refrigeration, and other industries.

(6) Methods and processes for producing sugars, furfural and derivatives, synthetic rubber and related polymers for use in case of an emergency, and fermentation products directly or indirectly.

(7) Manufacture of agricultural and motor fuels.

(8) Analytical and physical investigations on residues.

(9) Industrial and agricultural surveys (in cooperation with existing agencies).

Corn Utilization Investigations
(Northern Laboratory)

The Problem and its Significance: The United States had a surplus of about a half billion bushels of corn out of a production of around 2-1/2 billion bushels in the crop years of 1939-40.

Various factors responsible for this surplus are improvements in corn growing, mechanization and fewer work animals, and a downward trend in hog numbers in recent years. Because of these and other influences, total requirements in the last ten years have decreased approximately 200 million bushels annually. This reduction in requirements has been followed by a reduction in acreage which, however, has been offset by increased yields from the widely adopted hybrid varieties and this effect is still growing. Additional appreciable decreases in acreage are unlikely because most corn farmers have no other choice of crops that offer better returns. Furthermore, present world conditions are not apt to stimulate an expansion of foreign markets for American corn.

Hence, the need for new uses or outlets for surplus corn are great. Its importance is indicated by the fact that corn represents from one-fifth to one-third the value of all farm crops grown in the United States.

Industrial utilization of corn has been a large scale practical operation for fifty years. Basic reasons for this are (1) the relatively low price of corn, and (2) the high starch content of corn. That portion of the corn crop used industrially amounts to about nine percent, equivalent to some 200,000,000 bushels, which, together with the surplus, usually controls the price the farmer receives for corn. More than four-fifths of the corn used by industry enters the corn dry-milling and corn wet-milling industries, the remainder being used in the manufacture of breakfast food, alcohol, and cereal beverages. During the past fifteen years the consumption of corn by the industries has been quite constant.

Practically no attack has been made by industrial companies, universities, Federal or State agencies on the development of new industrial uses for corn, its products and their derivatives. The corn processing industries' research organizations, which are relatively small, have necessarily focused their activities on plant problems and on food uses.

Any significant expansion of the industrial utilization of corn must depend basically on the development of new and more extended uses for starch or products derived from it. Such expansion may take place under one or more of four types of processing industries, namely, dry milling, wet milling, fermentation for industrial chemical products, and fermentation for the production of motor fuel. Of these, wet-milling methods for the production of starch and the byproducts protein and oil offer the most promise for future expansion. Because of the excellent competitive position of cornstarch, which is probably the cheapest pure organic material available for large volume industrial utilization, it seems almost inevitable that the acquisition of application of basic information on starch and its derivatives should result in a wide expansion of their present industrial utilization. Preparation of chemicals from corn by specialized types of fermentation appears less promising than fermentation for motor fuel, primarily because of the magnitude of the potential market for alcohol as a motor fuel. This use, if economically feasible, would in itself easily absorb our surplus of corn.

Research on corn and its products and byproducts is of special significance in a time of national emergency. Strategic and critical raw materials such as tin, rubber, starch, and drying oils offer opportunities for the development of replacement materials of great value both to the civil population and the armed forces. For example, rubber substitutes and extenders from cornstarch and corn oil, plastic containers for processing of foods from the protein of corn, and starch and drying oils to supplement the dwindling supplies of these materials available from foreign sources, as well as motor fuels to supplement our supplies of gasoline.

Plan of Work: For the development of new and extended uses for corn, the following broad fields will be investigated:

(1) Processing and engineering problems dealing with new and more economic methods for producing starch, protein, and oil so as to make the products more available to industry.

(2) Application of the unique physical characteristics of starch in expanding outlets in the adhesives, textile, and paper industries, and in developing new markets in other industries.

(3) Chemical modification of starch with cheap raw materials for the production of materials having large volume outlets in the plastics, construction, and chemical industries.

(4) Conversion of corn sugar by chemical or physical processing to products of potential usefulness for industrial purposes.

(5) Modification of corn oil by chemical or physical means to a drying oil for use in the paint and varnish industry.

(6) Adaptation of corn oil for the production of rubber-like structural materials, flotation agents, lubricants, and surface coatings.

(7) Pilot plant production of motor fuels from corn to establish yields, cost, and operating data by fermentation and other procedures.

(8) Evaluation of motor fuel from corn in regard to economy, power, anti-knock qualities, and other important properties by carrying out engine and field tests.

(9) Utilization of corn derivatives as blending agents with the purpose of imparting desirable characteristics to motor fuels.

(10) Mold and bacterial fermentation of corn and derived products for production of valuable chemicals.

(11) Determination of the physical and chemical composition of corn and its constituents to aid in finding types and varieties best suited for specific purposes.

(12) Surveys on the practicability of any new use discovered as well as on the location, quantity, quality and condition of the raw materials to be used (in cooperation with existing agencies).

Wheat Utilization Investigations
(Northern and Western Laboratories)

The Problem and its Significance: Since the end of the World War the world market for wheat has very materially decreased whereas exportable surpluses have increased. As a result stocks of wheat have piled up and the world price has been so low that American farmers can no longer produce wheat profitably for the export trade. This is the principal reason new outlets or uses are needed in the United States for from 100 to 200 million bushels of wheat annually, our usual excess production over home needs.

Market prices for other grains usually follow closely the world wheat price. So when wheat is low the farmer finds no advantage in shifting to other grains. In fact, in some sections of the country, owing to climatic and other conditions, wheat is the only crop the farmer can produce.

The prospect of the wheat surplus problem of this country being solved as a result of improvements in the world market situation for wheat, either during the period of the present European War or in the reconstruction period that must follow, is extremely unpromising. The only belligerent countries in a position to take our surplus production of wheat have adopted a policy of buying grain from countries other than the United States. After the war the warring countries are likely to be near financial exhaustion so that their purchases of wheat will have to be kept at a minimum. Thus it will be seen that the prosperity of many American farmers is likely to depend on finding new uses for wheat.

In a national emergency, the primary use of wheat is for food. This has been true in the past and will be the case in the future. On the other hand, there are possibilities in the use of wheat protein for plastics and wheat starch for special industrial uses. In a large measure, the program for corn is applicable to wheat, particularly low-grade wheat, which economically may compete with corn in the industrial field.

Plan of Work: Wheat is about 75 percent starch, 14 percent protein, and 2 percent oil. So there must be, above all, new outlets for starch and it would be very desirable to have new ones for the protein and oil. Therefore, the plan is to continue the extensive research program as outlined below:

(1) Study properties of wheat starch as a basis for development of special uses.

(2) Development of new products from wheat starch by chemical treatment and biological changes such as those produced by molds and bacteria.

(3) Investigation of the properties of wheat, especially when low grade or damaged, as motor fuel.

(4) Investigation of the properties of wheat proteins and efforts to extend their uses and find new uses for them.

(5) Engineering studies to lower the costs of producing starch and proteins so as to make the products more available to industry.

(6) Analytical studies of physical and chemical composition of wheat and its constituents to aid in finding types and varieties best suited for specific uses.

(7) Surveys to determine the most promising possibilities for using wheat and wheat products in industry and where the industries are with relation to the supplies of available wheat (in cooperation with existing agencies).

Due to the great importance to both the Northern and Western areas, research on this commodity will be carried on in the Northern and Western Regional Laboratories. Careful arrangements have been made for the coordination of the work of the two laboratories on wheat. Wheat starch and oil will be studied at the Northern Laboratory, while wheat protein will be investigated at the Western Laboratory. The plan of work as given above deals with the research problems to be undertaken at both laboratories.

Cotton Utilization Investigations
(Southern Laboratory)

The Problem and its Significance: About 13 million bales of cotton lint and 5 million tons of cottonseed are produced annually in the United States. The cash income from cotton lint averaged 1300 million dollars from 1920 to 1929, but since 1929 annual cash income (exclusive of Government payments) has averaged only 600 million dollars. Average annual cash income from cottonseed, over the same period, declined from 130 million to 86 million dollars, while farm value of cottonseed (cash income plus the value of seed retained on the farm and the value of seed exchanged for meal) declined from 180 million to 120 million dollars. In spite of the restricted production of American cotton during the past few years, enormous carry-overs have been piling up with recurring frequency. The world supply of American cotton lint on August 1, 1939, was nearly 26 million bales, a quantity equal to nearly 2-1/2 times last year's world consumtpion of American cotton. If the production of cotton in the United States is to be maintained at anywhere near the levels of the late 1920's or even at those of the past 5 or 6 years and sold at a price representing a fair return to producers, increased outlets for cotton lint must be found. And if the severe drop in income from cottonseed is to be restored, improved and extended uses for cottonseed and its products must be found.

Cotton is the major crop on 1.5 million farms, and of all plant crops it is our greatest source of cash income. Cash income from cotton and cottonseed in the 10 principal cotton-growing states accounts for about 1/2 of the total cash income of farmers of these states from all crops and livestock combined. About 12 million of our people derive their principal support from the growing, ginning, handling and processing of cotton.

Cotton Lint

Cotton Products and Processing Machinery and Methods of Manufacture. More than 98% of the cotton consumed in this country is mechanically processed into woven and knitted fabrics, twine and cordage yarns, wadding, batting, absorbent cotton, etc., where cotton retains practically all of its basic physical properties. The development of new and improved Cotton Products and the development of new and improved Processing Machinery and Methods of Manufacture will bring about an increased consumption of cotton.

The development of new and improved Cotton Products is a direct method of increasing the consumption of cotton. In the face of increasing competition from paper, jute, rayon and other materials, in both domestic and foreign markets, large-scale carefully planned research of this nature is urgently needed, and yet the cotton-textile industry, owing largely to the diversity of interests among its member mills, and the highly competitive conditions existing within the industry, has never undertaken an industry-wide research program of this nature. Although all fields of usage offer opportunities for extending the utilization of cotton, this type of research should be particularly productive in the field of industrial uses where physical properties and price are the major factors which determine the types and quantities of materials used, and in which field there is no definite limit, other than that determined by price and physical properties, to the quantities of cotton which may be consumed.

Although considerable research is needed in the development of present well known types of cotton products (that is those which are spun, knit, woven, etc.) there is also a vital need of research that will embrace other types of products such as those which may be made of unspun cotton fibers bonded with adhesives; products formed by the lamination of unspun fibers with yarns, fabrics and other materials; and other products utilizing cotton in some form as an essential part. A fertile field also exists for research applied to the development of yarns and fabrics containing cotton mixed with one or more other fibers with the purpose of obtaining certain characteristics not obtainable in yarns and fabrics made wholly from cotton.

The quality and cost of cotton products are dependent in great measure upon the types of machinery and the nature of the methods which are used in their manufacture. In the case of most cotton fabrics, the cost of processing amounts to about 50% of the mill cost of the fabric. In many articles made from cotton fabrics, such as bags, the processing cost of the fabric alone is more than 1/3 of the cost of the finished article. Substantial reductions in the cost of manufacturing cotton fabrics through the development of new and improved Processing Machinery and Methods of Manufacture would result in an appreciable increase in the consumption of cotton, especially in the case of fabrics for industrial uses, where fabric price is a major factor in competition with other fibers and materials. Research of this nature is closely allied to research on the development of new and improved Cotton Products and will contribute to the success of that part of the program. An intensive effort to develop new and improved Processing Machinery and Methods of Manufacture is urgently needed.

Chemical Finishing. Attractiveness and general sales appeal of cotton fabrics for clothing in household use are largely governed by properties which are capable of being imparted or improved by Chemical Finishing. The specific properties which influence the demand for and use of cotton textiles are color, luster, softness, crispness, resilience, crease-resistance, moisture absorption, water-proofness, fire-proofness, mildew-proofness, etc. The treatments designated as Additive Finishing (i.e., the addition to the cotton of cellulose esters or ether finishes, synthetic resins or other suitable chemical compounds) is capable of developing or improving many of these properties, and research in this field offers the best possibility of immediately increasing the utilization of cotton. The treatments designated as Modified Finishing (i. e., the action upon the cotton of caustic soda, sulfuric acid, organic salts of nitrogen bases or other suitable reactants) is also capable of affecting certain of these properties and research in this field should ultimately be productive of greater utilization of cotton. Improvements and economies in the Bleaching, Dyeing and Printing of cotton would result in cheaper and more attractive products and research in this field should also broaden the markets for cotton textiles.

Fiber Properties and Structure. In a program of research devoted to finding new and extended uses for cotton, there is need for considerably more fundamental information on fiber properties and structures than is now available. Information of this nature is needed in all phases of the applied research program on cotton fiber, but is especially helpful in the development of new and improved cotton products to meet the requirements of specific uses. Fundamental information on fiber properties and structure also provides a basis for research to alter the natural properties of cotton fibers to enhance their values for specific uses. From the standpoint of efficiency and mutual helpfulness, this research must and will be carried out in close cooperation with those agencies in the laboratory working toward the more technological objectives of the program.

Utilization Surveys. Efficient operation of the program to find new and wider outlets for cotton products will entail the collection, interpretation, and constant use of many different types of economic and statistical information. Such information is a necessary adjunct to technological and other types of information in selecting the most worthwhile projects on which to work and in evaluating the industrial possibilities of the products of research as they are developed. Such surveys will be conducted in cooperation with existing agencies.

Cottonseed

Approximately 65 pounds of cottonseed are produced for every 35 pounds of cotton lint. Cottonseed oil represents about 56 percent of the total value of the direct products obtained from cottonseed. Substantial losses in potential value of available cottonseed oil occur during processing and storage.

Oil. Hydraulic pressing, which currently is most used, and expeller pressing, which is used to a limited extent, permit from 4 to 6 percent of oil to remain in the meal, and since the oil is the most valuable component

of the cottonseed, it is urgent that attention be directed to solvent extraction or improvements in the pressing procedures to recover greater percentages of oil. Improvements and economies are also needed in the other processing operations. In order to improve the quality of the products and reduce cost of operations by the development of economical and, where possible, continuous processes, it is very desirable that the oil mill and oil refinery operations be carried out on a fairly uniform year-round basis rather than on a seasonal basis as is now generally the case.

Due to its chemical nature, cottonseed oil is susceptible to rancidity. Rancidity accounts for large losses yearly in the value of cottonseed oil produced. A fundamental program of research on the causes and prevention of rancidity is urgently needed.

Cottonseed oil contains small amounts of valuable constituents such as phosphatides, sterols, antioxidants, enzymes and pigments. The isolation, separation, identification and fundamental study of these substances, as well as the major fatty acid and glyceride components of the oil comprise very promising fields of research.

It is important that cottonseed oil and its various products be exhaustively studied in order that its useful characteristics in the channels of trade it enters be more widely known, and thereby a better chemical utilization of cottonseed oil be furthered. There is a large field of opportunity for utilizing cottonseed oil by the production of such industrial products as detergents, leather and textile fabrics, lubricants, etc.

Protein Meal and Cake. Approximately 2 million tons of protein meal and cake valued at $47,000,000 and equivalent to 31 percent of the value of the cottonseed are produced annually. Considerable loss in value of the protein content is incurred during expeller and hydraulic pressing of the oil because of a high degree of denaturation, which makes the meal and cake unsuited for commercial uses except as feed. If a protein meal can be produced efficiently and economically, consisting largely of undenatured protein, it will then be possible to undertake highly important lines of research directed to the production of such industrially useful products as films, fibers, plastics, textiles (wool substitutes) adhesives and sizes, as well as the preparation of pure and modified proteins, amino acids, carbohydrates, etc.

Linters. Approximately 1 million running bales of linters valued at $12,000,000, equivalent to 8 percent of the value of cottonseed are produced annually. Much of this value of the linters is based on the value of the cellulose nitrate and other modified esters and ethers that are obtained by chemical conversion. Certain of these products, such as smokeless powder, are essential for national defense. If the present high cost of processing linters for chemical conversion can be lowered, their use can be widened through the development of new and improved conversion processes. It is also desirable that more information be obtained on the technology and reactions necessary to improve and increase the use of linters in preparing fibers, films, sheets and lacquer finishes.

Hulls. Approximately 1 million tons of cottonseed hulls valued at $7,000,000 equivalent to 4.5 percent of the value of cottonseed are produced annually. About 10 percent of the hulls are processed for hull fiber. The residue from the hull fiber operations appears as hull bran, which is used in a limited quantity for mixture with protein meal in feed. Unprocessed hulls are utilized mostly as feed for livestock. The extensive production of cottonseed hulls collected and concentrated at the oil mills should make possible the development and establishment of industries using this product as a raw material.

Cotton is an important material in the time of a national emergency, not only in those uses which are normally and thoroughly understood, such as cotton linters for explosives, cotton fabrics for army use, from tropical uniforms to tents and gas mask carriers and cottonseed oil for cooking; but also for the production of plastics from cottonseed meal, new fibers for cordage and special soap fats to replace palm oil and copra. These and many other possibilities indicate the need for thorough-going research on cotton and its byproducts in the time of a national emergency.

Plan of Work: For the development of new and extended uses for cotton, the following broad fields will be investigated:

Cotton Lint

(1) Mechanical processing problems dealing with the development of new and improved processing machinery and methods to lower the cost and improve the quality of cotton products.

(2) The development of efficient and economical machinery and methods for producing cotton yarns and fabrics by means other than those now in use.

(3) Determination of the basic physical and other use requirements for new or proposed cotton products.

(4) Experimental development of cotton products by the application of known techniques, designed to meet the use requirements.

(5) Laboratory testing, including the development of new tests and equipment where necessary, to determine whether or not the cotton products so developed are ready for actual service tests.

(6) Service testing to determine if the cotton products satisfactorily meet all of the use requirements and, where the products fail, to indicate where further work is needed.

(7) Technological information, such as relationships between fiber properties, yarn properties, and the utility of cotton products.

(8) Chemical finishing of cotton textiles, either by the addition of suitable chemical compounds, or by the action upon the surface of the cotton fiber of suitable chemical reactants, to develop or improve specific properties (such as luster, softness, crispness, resilience, crease-resistance, moisture absorption, water-proofness, fireproofness, mildewproofness, etc.) which influence the demand for and use of such textiles.

(9) Improvements and economies in the bleaching, dyeing and printing of cotton for the purpose of broadening the market for cotton textiles by producing cheaper and more attractive products.

(10) Fundamental information on cotton fiber properties and structure in order to provide a basis for research to alter the natural properties

of the fibers, modify the structure, or prepare derivatives and thereby enhance the value of the cotton for specific uses.

(11) Analytical, physical and physical chemical investigations on cotton lint.

(12) Surveys to find new and wider outlets for cotton products, to determine the practicability of any new use discovered, and to evaluate the industrial possibilities of the products of research as they are developed.

Cottonseed

(13) Processing and engineering problems relating to new, improved and more economic methods of processing cottonseed for the production of oil, cake, meal, protein, linters, hulls, hull fiber, hull bran and derived products to improve yields, reduce costs and render these raw materials more available for industrial use.

(14) Chemical constituents of cottonseed, cottonseed oil, meal, protein, hulls, and hull bran to determine their nature, properties, uses and possible adaptation to the production of new or modified products of economic and industrial value.

(15) Odor and flavor stability and rancidification of cottonseed oil and the products in which this oil is used, including the influence of various natural and artificial antioxidants.

(16) Recovery, purification and use of various byproducts of the production, refining and other processing of cottonseed and cottonseed oil including foots, soap stock, acidulated soap stock, still pitch, winterizer cake and deodorizer condensate.

(17) Modification of cottonseed oil by chemical and physical means to produce "lauric-acid" type oils for the replacement of imported coconut, palm-kernel and babassu nut oils largely used for the production of free-lathering and hard water soaps.

(18) Isolation, purification and conversion of cottonseed cake, meal and protein for use in the production of adhesives, glues, sizes, fibers, plastics and related products.

(19) Cooperative research on and development of new and improved methods of harvesting, handling and storing of cottonseed as an aid in and in furtherance of their industrial utilization.

(20) Determination of physical and chemical properties and composition of cottonseed and all of its derived products as an aid in locating or developing strains and varieties adapted to specific industrial uses.

(21) Surveys (in cooperation with existing agencies) on the practicability of any new use or new product discovered or developed from cottonseed, as well as location, quantity, quality and condition of the raw materials to be used.

(22) Investigation of the properties of linters, both alone and in mixtures with other fibers, as an aid in developing materials for use in stuffing, packing, paper, and other felted material which can satisfactorily replace materials now in use and which are frequently imported.

(23) Improvement of the processing of linters for chemical conversion and lowering the cost of conversion in order to widen their use.

(24) Preparation of cellulose esters, ethers, and other derivatives from linters in order to determine the technology necessary to improve the products and thereby increase the use of these linters in the manufacture of fibers, films, sheets, lacquer finishes, explosives, etc.

Sweetpotato Utilization Investigations
(Southern Laboratory)

The Problem and its Significance: The average yearly production of sweetpotatoes is about 70 million bushels. In 1935, of a total crop of 73 million bushels, 3 million bushels were saved for seed, 46 million bushels were used on the farm for food, 23 million bushels were sold and 11 million bushels were fed to stock or lost. The feed market for sweetpotatoes is somewhat inelastic. As a consequence there is definite need for the development of industrial uses which will take care of surpluses of this product in the years of high yields and provide a market for the large quantity of culls and oversize sweetpotatoes which do not meet the grading requirements for food.

Sweetpotatoes are the second largest vegetable crop in the United States and the largest in the South. If the industrial utilization of the sweetpotato can be proved economically feasible, this crop would contribute to further agricultural diversification in the South and provide for longer and more favorable rotation in areas of single or limited cash crops.

Approximately 1.2 billion pounds of starch were used in 1937 in the United States for industrial purposes, and of this amount about 38 percent (or about 480 million pounds) constituted imported foreign starches. Sweetpotatoes are high producers of carbohydrates, chiefly starch, and sweetpotato starch is well adapted to replace tapioca and other imported starches in the manufacture of textiles, paper, and other industrial products. Almost 3 million pounds were used last year. Much fundamental information is required concerning the structure and properties of sweetpotato starch in order to adapt it to new and improved industrial uses.

The sweetpotato starch industry is still in its infancy, and there are many problems of storage and manufacture, such as prolonging the period of operations beyond the harvest period and development of continuous and more economical methods of production.

In addition to the fibrous portion of the sweetpotato, now recovered from the starch process largely as feed, there are present water-soluble materials to the extent of about 25 percent of the starch content. In the present manufacturing process all of these solubles are lost and it is obvious that the economic recovery of these materials provides a basis for increasing the revenue from this commodity.

In view of the ability of sweetpotatoes to produce an exceptionally high yield of starch and other carbohydrates per acre under conditions where other crops such as corn, sugar cane and sugar beets do not thrive, this commodity has an important place in national defense considerations, especially in the event of any suspension of our off-shore supply of sugar and other carbohydrates.

More specifically, sweetpotatoes offer great possibilities for the substitution of sweetpotato starch for imported cassava and other root starches in special uses to which other starches are not adapted.

Plan of Work: For the development of new and extended uses for sweetpotatoes, the following broad fields will be investigated:

(1) Cooperative agronomic-chemical investigations on the development and improvement of sweetpotato varieties and their production for such characteristics as high yield and quality of starch and other products.

(2) Cooperative work on and development of new and improved methods for harvesting, handling and storage of sweetpotatoes for starch manufacture, feed, and flour.

(3) Investigations of the structure and properties of sweetpotatoes as a basis for improving the starchmaking process.

(4) Research on all phases of the starchmaking process to lower costs, improve products and byproducts and encourage the establishment of new plants.

(5) Investigation of the byproducts of sweetpotato starch manufacture to develop new and satisfactory methods of recovery and to discover new and improved outlets.

(6) Development and improvement of processes for production and uses for sweetpotato flour.

(7) Development and improvement of processes for production and uses for derived products from sweetpotato starch and flour.

(8) Pilot plant operation of various processes developed to establish yields, costs and pertinent operating data.

(9) Analytical, physical and physical chemical investigations on sweetpotatoes.

(10) Utilization surveys to determine the most promising possibilities for the industrial utilization of sweetpotatoes and sweetpotato products and byproducts.

Peanut Utilization Investigations
(Southern Laboratory)

The Problem and its Significance: Approximately 1.5 billion pounds of peanuts, with a farm value of $47,000,000 were produced in this country in 1938. At the present time about 64 percent of this production is consumed for food and the food market is somewhat inelastic. As a consequence the hope of expanding present uses and creating new markets for peanuts and their products lies in the industrial field.

Peanuts are grown both alone and interplanted with other crops in all Southern states. The peanut is a leguminous plant and it is potentially a soil builder. The average yield of peanuts harvested as nuts during the 10-year period 1927-1936 inclusive, was 692 pounds per acre, but under the best conditions yields of 1,400 to 1,600 pounds per acre are frequently secured.

The expansion of peanut growing in suitable areas in the South is being encouraged as a substitute for the one-crop cotton system which is at present practiced there. To do this, it is necessary to expand the present industrial uses and develop new uses for peanuts and their derived products, such as edible nuts, oil, protein meal and cake and hulls.

The edible nuts account for approximately 80 percent of the yearly

crop, and this market is valued at about $38,000,000. Approximately 78 million pounds of oil valued at $5,000,000 are produced annually. Substantial loss in value occurs during the storage of the peanuts and the processing for oil.

Oil: Because of its chemical nature, peanut oil is susceptible to substantial loss in value, due to rancidity, which accounts for large losses yearly in the value of peanut oil. A fundamental program of research on the causes and prevention of rancidity is urgently needed. Peanut oil contains small amounts of valuable constituents, such as phosphatides, sterols, antioxidants, enzymes and pigments. The isolation, separation, identification and fundamental study of these substances, as well as the major fatty acid and glyceride components of the oil, comprise very promising fields of research. It is important that peanut oil and its various products be exhaustively studied in order that its useful characteristics, the channels of trade it enters be more widely known and thereby a better chemical utilization of peanut oil be furthered. Increased utilization of peanut oil can be brought about through the improvement of methods for producing detergents, finishes, pharmaceuticals and other industrial products. The inherent stability of peanut oil forms a basis for a very promising development in fields now monopolized by certain imported oils.

Protein Meal and Cake: Approximately 65 thousand tons of protein meal and cake, valued at $1,500,000 are produced annually. Current methods of processing cause changes in the cake which make it unfit for most industrial uses. Little is known about the applicability of modern oil extraction methods to the processing of peanuts or about the character of peanut protein so obtained. If a protein meal consisting largely of undenatured protein can be produced efficiently and economically, it will then be possible to undertake highly important lines of research directed to the production of such industrial useful products as films, fibers, plastics, textiles (wool substitutes) adhesives and sizes, as well as the preparation of pure and modified proteins, amino acids, carbohydrates, etc.

Hulls: Investigations of peanut hulls, especially those concentrated at shelling and processing plants, should make possible the development and establishment of industries using this product as a raw material.

Peanut protein has been used for the production of textile fiber from which a wool-like material has been woven. This offers great possibilities for wool replacement in the time of a national emergency. Moreover, because of its inherent stability, peanut oil offers important possibilities in the textile industry as a substitute for olive and other imported oils.

Plan of Work: For the development of new and extended uses for peanuts, the following broad fields will be investigated:

(1) Processing and engineering problems relating to new and more economic methods for the production of peanut oil, cake meal, and protein, to improve yields, decrease costs and render these products more available for industrial use.

(2) Chemical constituents of peanuts, peanut oil, meal and protein to determine their nature, properties, uses and possible adaptability to the production of new or modified products of economic and industrial value.

(3) Improvement of the keeping quality of peanut oil and the products in which this oil is used, as well as the natural antioxidant of peanut oil and its effect on the stability of processed products containing this oil.

(4) Recovery, purification and use of various byproducts of the production, refining and processing of peanuts and peanut oil including foots, soap stock, acidulated soap stock, still pitch, winterizer cake and deodorizer condensate.

(5) Modification of peanut oil by chemical and physical means to produce products for specialized uses such as imported hard waxes for use in the leather, cosmetic, pharmaceutical and metal goods industries and to replace certain imported oils in the textile and related industries.

(6) Isolation, purification and adaptation of peanut protein for use in adhesives, glues, sizes, fibers, plastics and related products.

(7) Cooperative research on and development of new and improved methods of harvesting, curing, handling and storing of peanuts as an aid in and in furtherance of their industrial utilization.

(8) Determinations of physical and chemical properties and compositions of peanuts and all of their derived products as an aid in locating or developing strains and varieties best adapted to specific industrial uses.

(9) Surveys (in cooperation with existing agencies) on the practicability of any new use or new product discovered or developed from peanuts, as well as location, quantity, quality and conditions of the raw materials to be used.

Apple Utilization Investigations
(Eastern and Western Laboratories)

The Problem and its Significance: The 2,423,000 acres devoted to growing apples produce annually 150 million bushels of fruit valued at about $110,000,000. The "commercial crop" amounts to only 60 percent (90 million bushels) of this total, approximately 20 percent (30 million bushels) is processed for such products as cider, brandy, vinegar, dried apples, canned apples, canned apple sauce and other apple products, and the remaining 20 percent of the crop stays on the farm to be utilized by the grower in the best way possible. Obviously, the grower himself cannot utilize this huge bulk of 30 million bushels and a large part is therefore wasted.

Increased competition from other fresh fruits, particularly citrus, and the large loss of our apple export trade, have been mainly responsible for the accumulation of surpluses of marketable apples and the unsatisfactory price conditions now prevailing. Shipments to foreign markets for the 5-year period, 1927-31, averaged 17.5 million bushels annually, while for the period 1932-36 the average dropped to 10.6 million bushels. During the past half dozen years the average price to apple growers has been only about 70 cents a bushel. In addition to large surpluses of market grade apples, enormous quantities of culls are produced annually,

[illegible]

for which new and more profitable uses are urgently needed. There is also an annual accumulation of about 64,000 tons of pomace from existing vinegar and other byproduct plants, which is largely wasted. The culls and lower grade fruit at present constitute a serious marketing problem and act as an entering wedge in lowering the price obtained for first grade fruit.

It is not practical to curtail sharply production of tree fruits such as apples since a tree once in bearing will continue to increase in production for several years and it is questionable whether sharp curtailment in production of apples would be desirable even if it were possible, as seasonal variations in production are great and are due to circumstances beyond control, such as weather conditions and the tendency of apple trees to bear in alternate years.

The 1935 census of agriculture lists, 2,358,781 farms having apple trees, 40 percent of the crop (60 million bushels) being produced by small, individual farm orchards located in all but two states. The industry is widely scattered, difficult of organization, and not in a position to carry on research looking toward utilization of the crop. The problem of surplus utilization is therefore national in scope.

New products need to be developed to provide a means of diverting surpluses in years of large yeilds. Such a program of extended uses for apple products must be geared to the economic conditions existing in the industry for smooth and effective operation. It must be broad and diversified to handle efficiently and economically the large quantities of material available and must also be flexible because of fluctuations in the amount of raw material available in any one year.

In the event of a national emergency research on apples would assume considerable significance. Apple juice, apple juice concentrates, and dried apple products would be of great importance in the food supply for both the armed forces and civil population. The utilization of apple pomace as a source of pectin, useful in the preparation of food products and for certain medicinal purposes, represents one line of research which would be of great value.

Plan of Work: (1) New Food Products: The development of new types of apple juice, concentrated juice and sirup, having improved flavor characteristics and stabilized for year-round consumption will be attempted. This investigation will include a study of methods of clarification, homogenization, sterilization, and preservation; containers; and storage conditions.

(2) Frozen Apple Slices: Investigations will be conducted on the preparation of frozen apple slices and the possibilities of their use for various uses; pretreatment for prevention of discoloration and toughening of tissue; and the nature of ice formation during freezing and of changes in crystal structure during storage.

(3) Pectic Substances: Methods will be investigated for the production of pectic substances to improve the quality, lower the cost and prepare products with specific characteristics suitable for new industrial uses.

(4) Analytical and Physical Chemical Investigations: Comprehensive investigations will be undertaken to secure such information as is needed for this research program on the utilization of apples as well as a systematic investigation on the chemical composition, structure and properties of compounds and products derived therefrom such as vitamins, pectin, cuticle waxes, proteins, enzymes, and fibrous substances.

(5) Cuticle Wax: It is planned to investigate means for economical recovery of cuticle wax from apples and apple waste and to develop new industrial uses for this wax, its constituents, and derivatives.

(6) Pilot Plant Development: The plan consists in: demonstration of the technical practicability of new processes for the utilization of apples and apple products; development of designs and specifications of processing equipment and preparation of cost estimates of operation for processing apples in commercially significant quantities; acquisition of such engineering data as may be required by the exigencies of particular developments.

(7) Industrial and Agricultural Surveys: In cooperation with existing agencies, surveys will be made of the areas of production and the quantity, quality and condition of the varieties of apples available for industrial utilization. Due consideration will be given to the evaluation of the effect of trends in production, horticultural and processing practices on potential future industrial utilization of apples, collection and interpretation of processing, distribution and marketing information, and data on consumer requirements with respect to new products derived from apples, all in relation to competing products and raw materials.

Due to the great importance to both the Eastern and Western areas, research on this commodity will be carried on in the Eastern and Western Regional Laboratories, and the above plan of work deals with research problems to be undertaken at both laboratories. Careful arrangements have been made for the coordination of the work based primarily on varietal differences and resultant different product characteristics. In addition all work relating to frozen pack technology will be performed at the Western Laboratory.

Vegetable Crop Utilization Investigations
(Eastern and Western Laboratories)

The Problem and its Significance: Practically without exception during every crop year, surpluses of vegetables exist. Limited purchasing power of consumers and the recognized limit of consumption as foods or feeds prevent any far-reaching removal of surpluses either through increased value of purchases or by the consumption of more vegetables by each consumer. There remains,

however, the possibility of utilizing vegetables and their products and by-products in ways that may be described as scientific, chemical and technical. The work on vegetables in the Eastern and Western Regional Laboratories will be directed toward the development of such uses.

In many of the trucking areas farmers have only the fresh produce market as an outlet for their products. Growers, who have additional outlets, such as canneries and freezer plants, are in a better bargaining position. This position will be still further improved if there should also come into existence an additional consumer, such as the manufacturer of industrial products for which vegetables supply part or all of the raw materials.

The existence of supplies of vegetables over the amounts needed by the produce markets and by the food and feed processors reduces very greatly the prices of those portions of the crops that are actually sold and in addition directly or indirectly results in the total loss of income from a considerable part of the crops.

A summary of the 1938 volume of vegetable materials for which increased markets are needed is given as follows:

Cabbage	283,000 tons	Tomatoes	31,000 tons
Onions	134,000 tons	Spinach	29,000 tons
Carrots	65,000 tons	Celery	20,000 tons
Lettuce	56,000 tons	Beets	19,000 tons
Cucumbers	55,000 tons	Cauliflower	9,000 tons
Snap Beans	40,000 tons	Green Peas	6,000 tons

In addition there exists the possibility of turning wastes from food processing plants into merchantable materials by converting them into products which can be used in industrial manufacture.

The maintenance of an adequate food supply, both among civilians and in the armed forces, is indispensable to national morale and safety in time of emergency. The most serious threat to a full and well-balanced food supply now discernible is the possible shortage of tin for canned food containers. Immediate steps should be taken to meet this threat. Means of preserving vegetables by methods which do not require tin containers should be perfected as rapidly as possible. Frozen preservation, in particular, should be encouraged through the development of carefully engineered low-cost processes, on the basis of accurate knowledge of biological, physical, engineering, and economic factors involved. Efforts should be made to develop practical portable, frozen-storage equipment, with special reference to tropical conditions. Improvement in methods for transporting frozen foods economically is urgently needed. Measures should also be taken in the event of an emergency to provide the technical direction necessary to organize the decentralized storage of frozen foods in the refrigerated locker plants which are now widely scattered over the country.

Plan of Work: (1) Frozen-pack Technology: Investigations of freezing preservation of vegetables will be enlarged and will include basic research on the chemical, physical, physiological, and cytological behavior of vegetable

tissues and of enzyme and microorganisms affecting these tissues at low temperature and all pertinent chemical, physical, biological and engineering phases of vegetable handling, pretreatment, freezing technique, and subsequent low temperature storage and transport. Information so obtained will serve as a basis for improvement of frozen vegetable products. Consumer and market preferences, essential costs of production, distribution, and other factors will be thoroughly investigated from the standpoint of developing new and extended outlets for frozen products.

(2) Development of Industrial Products: Studies will be made of the constituents of vegetables to determine which ones may be useful in industry or to transform naturally occurring constituents into products of industrial value.

(3) Utilization of Processing Wastes: Intensive effort will be devoted to the development of new methods for the utilization of wastes accumulating at packing houses, canneries, and freezing plants and of wastes left or accumulated in the field. The possibilities of preparing humus materials for use in soil improvement will be thoroughly investigated. Biological processes for the production of enzymes or other special chemical compounds of industrial or therapeutic value will also be investigated. Extraction and purification of valuable ingredients such as waxes, vitamins, acids, and other substances will be attempted whenever the practicability of such utilization is suggested by the results of analytical or other investigations.

(4) Constituents of Vegetables: A systematic examination of various vegetable materials will be carried on to determine as completely as possible the constituents present and to develop methods of preparation with particular emphasis on those known to have possible industrial or therapeutic use, such as vitamins, enzymes, amino and other organic acids, pectins and inorganic compounds. Exhaustive examinations will also be made of the lesser known and unknown constituents by methods involving spectroscopic and other refined methods. Special emphasis will be placed on the determination of the physical and chemical properties of pectin and derived products as a basis for the production of low cost pectin for industrial uses.

(5) Pilot Plant Development: Equipment of an engineering character as regards design and materials of construction, but limited to such size as may be required to obtain adequate and essential engineering and economic data will be procured, installed and operated to demonstrate the technical soundness of processes of producing from vegetables new products for industrial utilization.

(6) Economic Surveys: Surveys will be made (in cooperation with existing agencies) to determine and evaluate the utility and adaptability of new vegetable utilization products. Basic surveys will be used also to determine the size and geographical distribution of raw material supplies, small and large factory sites, transportation costs, prospective markets, the effect of new and competing products upon price levels in existing markets, and the distribution and capacity of related processing industries to those factors which may affect the commercial success of the new developments.

Due to the great importance of vegetables in both the Eastern and Western areas, research on this commodity will be conducted in the Eastern and Western Regional Laboratories, and the plan of work as outlined above deals with the research problems to be undertaken at both laboratories. Careful arrangements have been made to coordinate the studies; frozen-pack technology will be investigated exclusively in the Western Laboratory; other phases of the work have been apportioned on the basis of the importance of the individual vegetable crops in the Western and Eastern areas.

Tobacco Utilization Investigations
(Eastern Laboratory)

The Problem and its Significance: Great changes in the demand for the manufactured products of tobacco have occurred during the past 25 years. These changes have necessarily been reflected in the producing areas, requiring the alteration of certain cultural practices, and reducing the production of fire-cured, dark air-cured, and cigar tobaccos, while greatly expanding the production of the flue-cured and Burley types.

These changes in consumption toward the lighter tobaccos have in recent years brought about serious economic crises, made more difficult, especially in the export field, by the competition from the steadily increasing production of tobacco in foreign countries, by trade barriers and military operations. Recurring surpluses have developed. In the fire-cured producing areas the producers have not been able to adjust their farm economy rapidly enough to keep pace with the decreasing demand for the fire-cured products; or, if they shift to the Burley type in Kentucky and Tennessee, or the flue-cured type in Virginia, they may add to an oversupply of these types. In the cigar leaf producing areas many growers have shifted from tobacco to other crops like potatoes, and there have had to meet the distressed conditions recurring in the potato industry. Recent world conditions have intensified the general problem, as witnessed in September, 1939, after the declaration of war in Europe. Then the British government impounded its foreign exchange resources and has since ordered, as a war measure, the cessation of tobacco buying for British accounts and shipment of American tobacco to the British Isles. This act in itself closed the then current market for more than 250 million pounds of flue-cured tobacco, and developed the largest surplus of flue-cured tobacco in a decade. In addition to the need for development of new and extended uses for surplus tobacco there exists the problem of finding outlets for the disposal of a variable quantity of low grade tobacco which occurs in every crop.

Tobacco is important in the economy of every section where it is commercially produced, because it is the principal money crop on most of the farms on which it is grown. Tobacco ranks fourth among our principal crops, and is commercially grown in 20 states. The annual production for the ten-year period 1929-1938 has averaged approximately 1,360,000,000 pounds grown on 1,700,000 acres. The farm value has ranged within the same period (1929-1938) from 107 million dollars for the distressed 1932

crop to 319 million dollars for the 1937 crop, with an average value during the past five years of approximately 275 million dollars.

The need for new uses and outlets for most of the types of tobacco has recently become especially acute, owing to the factors noted above, as well as others, which are seriously affecting the demands for the several types of American tobaccos resulting frequently in unsalable surpluses. Curtailment or change in both our foreign and domestic demands has necessarily taken place. New uses and enlarged outlets or improved processes may not only forestall further declines in the potential demand, but in certain cases they can reasonably be expected to increase the demand for tobacco and sustain the farm income from this crop.

The removal of the low grade tobaccos, which occur in every crop, out of the regular channels of trade for use in products other than the usual consumption channels of leaf tobacco, would enhance the value of the remaining more desirable portions of the crop destined for the manufacture of the usual tobacco products. Such inferior grades constantly maintain a volume that is regarded as a depressant upon the markets for more desirable leaf. Such surpluses fluctuate within a type from crop year to crop year, and vary as to types. Because of these variations, it is important that a program of investigation for new uses should include consideration of all of the principal types of tobacco.

Plan of Work: The development of new and extended uses and new and extended outlets for tobacco will be sought through the following:

(1) Studies on the production of and the extension of uses for nicotine, the most characteristic constituent of tobacco.

(2) Studies on practical methods of isolation and determination of commercial possibilities for utilization of tobacco constituents other than nicotine, about thirty of which are known.

(3) Processing studies on cigar tobaccos to improve quality and enhance their value.

(4) Studies on the relation between chemical composition and physical characters and quality of various tobaccos.

(5) Comprehensive physical-chemical and physical investigations will be undertaken to secure necessary basic data on tobacco and products derived therefrom.

(6) Equipment of an engineering character as regards design and materials of construction, but limited to such size as may be required to secure adequate and essential engineering and economic data, will be procured, installed, and operated to demonstrate the technical soundness of methods of producing new or improved products from tobacco and of new or improved methods of processing tobacco which originate in the laboratory.

(7) Technological studies will be made upon a broad comprehensive basis of the whole tobacco industry and they will be correlated with related agricultural and industrial operations.

(8) Surveys pertinent to the utilization of tobacco and its products will be made (in cooperation with existing agencies) and will include those relating to the kind, amount and distribution of raw material supplies, the adaptability of such supplies for conversion, the prospective markets for

proposed new products, and the expansion of markets for products already being made.

(9) Studies will be made pertaining to the collection of raw materials, farm and factory storage and transportation, cost data, and all other relative factors.

Milk Products Utilization Investigations
(Eastern Laboratory)

The Problem and its Significance: In the United States over 100 billion pounds of milk is produced annually. This has a value of about 2 billion dollars or about 20 percent of the total farm income, and approaches the combined value of cotton, wheat, and tobacco. Since milk and milk products are perishable, a surplus, in the sense that there may be a large carry-over from a period of flush production beyond the next one, does not exist. However, there are serious seasonal surpluses which, in their economic effects, present a challenge to improve the dairy industry of this country. While some adjustments may eventually be made through regulation of production, the main goal is to find means of converting surplus milk into marketable products whose manufacture and sale can be adjusted to the extremely variable supply of raw material.

Since milk for human consumption commands a price considerably in excess of that obtainable for non-food purpose, conversion into butter, cheese, and other food products represents a very important means for the profitable utilization of milk which cannot be consumed directly. However, there always remains from the manufacture of these foods a large surplus of the principal dairy byproducts, skim milk and whey. To find more profitable outlets for these materials is the present major problem toward which research attack must be directed.

Steps to bring about increased industrial utilization of skim milk must entail increased utilization of the several constituents, especially of the main constituents, casein and lactose. The inorganic salts and water-soluble vitamins have value, of course, in the preparation of animal feeds and concentrates. Considerable progress has been made in the consumption of domestic casein, its production having increased from about 8 million pounds in 1921 to about 67 million pounds in 1937. In the latter year approximately 120 million pounds of the casein whey was used in the manufacture of crystalline lactose and about 5 million pounds was fermented to make lactic acid.

Despite these advances, the skim milk employed in the manufacture of casein, lactose and lactic acid accounts for less than 5 percent of the 54 billion pounds of skim milk obtained in 1937, not to mention about 9 billion pounds of cheese whey and buttermilk. Inasmuch as the great bulk of these byproducts is at present fed on the farm, it is obvious that raw materials requisite to a large expansion of the casein and lactose industries are potentially available. The development of new and improved uses and methods of processing in connection with these components would result in such expansion, would tend to stabilize the market structure of

the dairy industry, and would bring a greater return to the dairy farmer.

Research on milk products in time of a national emergency would assume unusual importance. The development of a wool replacement fiber from skim milk would be of primary concern. Studies in this field should produce a material of great value to the United States in the event of a wool shortage. In addition, casein from skim milk lends itself to the development of many forms of plastics which can be used in a national emergency. Milk sugar, or lactose, has been used in the manufacture of explosives, and products from lactic acid (made from milk sugar) have certain characteristics which make them valuable in the plastic and resin field.

Plan of Work: An extensive research program will be prosecuted especially in connection with the protein and carboyhdrate present in milk by-products.

(1) Development of the utilization of milk proteins and other proteins for commercial purposes.
(2) Investigations of the production of milk proteins and other proteins for industrial and scientific uses.
(3) Investigations of the basic composition and properties of proteins to support (1) and (2).
(4) Investigations on the production and utilization of lactose and its derivatives.
(5) Surveys of the industrial utilization of milk and its products (in cooperation with existing agencies).
(6) Chemical engineering studies of costs, yields, and methods in developing commercial utilization of milk products.

Animal Fats and Oils Utilization Investigations
(Eastern Laboratory)

The Problem and its Significance: In the field of animal fats and oils the most serious surplus problem is encountered in connection with lard. The bad effect of the burdensome supply of lard is felt not only by the producers of lard but it causes general weakness in the prices of all domestic food and soap fats. There is also a close relationship between animal fat production and the corn crop, the major portion of which is marketed in the form of livestock. The present surplus of lard is due chiefly to the loss in recent years of the annual export outlet for about 300 million pounds of lard. Furthermore, these export markets are not always advantageous to the producer. As a consequence new outlets or uses are needed in the United States for about 300 million pounds or more of lard annually.

Animal fats and oils are byproducts and hence their production is not easily controlled. In addition they are perishable and can be stored for only limited periods. The prospect of a permanent solution of this surplus problem by improvement in the export market situation is not good. At present the United Kingdom, our most important market, is buying from countries attached to sterling exchange. With continuation of hostilities

European requirements for American lard are likely to increase, but during the reconstruction period that must follow, the present surplus situation will probably arise again. Thus it will be seen that the finding of new and extended uses for animal fats, especially lard, is of great importance to the American farmer and that this probably can best be accomplished by enhancing their value for present uses by improvement of quality and stability, and by the development of new technological uses and new products.

Animal fats and oils are important in national defense not only from the standpoint of the production of glycerine for explosives but they also offer great possibilities for research on the methods of production and preservation of the edible grades and on the production of special lubricants, cutting oils, soluble and metallic soaps, temporary corrosion resistant coatings, and intermediates suitable for the production of synthetic fibers and plastics, rubber-like materials, leather and textile finishing aids, etc., all of which are especially important for Army and Navy use.

Plan of Work: The above objectives will be sought through:

(1) Quality and stability studies.
(2) Development of methods of chemical modification including the preparation of surface active agents.
(3) Analytical and physical chemical research.
(4) Chemical engineering investigations.
(5) Utilization surveys (in cooperation with existing agencies).

The basis of the work will consist of fundamental studies of the chemistry, structure, composition, and properties of the animal fats and oils, their components, and the substances with which they are associated in nature, and their relationships to each other. This basic information will be correlated with that already available and applied to the improvement of the present methods of production, processing, preservation, and use so as to obtain more uniform products of better quality and of greater suitability for present uses, to extend these uses, and to develop new ones, and to lower the costs of production.

Potato Utilization Investigations
(Eastern and Western Laboratories)

The Problem and its Significance: Since the consumption of potatoes lies within rather narrow limits, a comparatively slight increase above average production often seriously depresses prices. Under similar demand conditions, it happens that small crops usually result in larger returns to growers than do large crops. Production is determined to a considerable extent on weather conditions during the growing season and in years when high acre yields occur the surplus of first grade potatoes reacts adversely on the market price. About 10 percent of the crop is culls, and the loss from diseased and frozen potatoes and shrinkage in storage may also amount to as much as 10 percent of the total crop. Because of these conditions, which necessarily exist in the potato-growing industry, there is a definite

need for the development of profitable means of utilizing, for other than direct food use, the annual supply of cull and second-grade potatoes and also of excess first-grade potatoes during years in which large surpluses occur.

Potatoes comprise the largest vegetable crop in the United States. The average yearly production during the ten-year period 1928-1937 was 371,844,000 bushels with an average yearly farm value of about 260 million dollars. During years of excessive production market prices are so depressed as to make the industry an unprofitable one. The opening of new channels for disposal of such surpluses would tend to stabilize the food market price and render an invaluable aid to the entire potato-growing industry. Similarly such channels would offer an outlet for disposal of the cull and low-grade portion of every potato crop which would add materially to the growers' income.

In considering the development of better means for the profitable disposal and utilization of cull and surplus potatoes, attention is naturally directed to the increased use of the crop for industrial purposes, especially since there formerly existed in the United States a substantial industry based on the processing of potatoes for starch manufacture. Under the conditions existing during the middle of the past century, potato growing for starch factories was a profitable enterprise, but the large scale development of the corn starch industry, which began about 1890 in the Middle West, rapidly changed this situation. Now potato starch manufacture in the United States is based almost entirely on the use of culls and is centered in areas where potato growing is most intensive, about 95 percent being produced in Aroostook County, Maine. On the average during the period 1925-38 only about 2 million bushels of potatoes were processed annually for starch manufacture. If this form of disposal could be increased to the point where from 15 to 30 million bushels of potatoes were required, the market price for potatoes for food use in surplus years would be held at a level which would make potato-growing a profitable enterprise, whereas under conditions now existing surplus years usually result in losses to the growers.

Research on white potatoes is of considerable importance to starch consuming industries in view of the emergency situation which now exists. The development of adequate supplies of high quality domestic potato starch would fill a need which exists as a result of the cutting off of our imports of this material from Holland. The present situation furthermore affords an excellent opportunity for gaining permanently the potato starch market in the United States, provided sufficient supplies of superior quality starch can be made available. Due to its peculiar physical properties potato starch should find important outlets supplementing our supplies of certain strategic and critical war materials.

Plan of Work: The development of new and extended uses for potatoes will be sought as follows:

(1) The development of improved methods for small- and large-scale manufacture of uniform, high-quality potato starch.

(2) The development of improved methods for microbiological control of processing operations in the manufacture of starch.

(3) Methods for the isolation and recovery of potato starch from frozen and otherwise damaged potatoes.

(4) The development of methods for the economical recovery and on means for utilizing potato starch byproducts, such as pomace and protein water.

(5) The modification of potato starch by physical and chemical treatments, in order to improve its characteristics for industrial purposes.

(6) Methods of preparation of starch derivatives, such as modified starches, dextrins, and sugar alcohols.

(7) Methods to extend the commercial utilization of starch, modified starch, dextrin, sugar alcohols, acids, and products derived therefrom, in such materials as medicinals, pharmaceuticals, essential oils, solvents, plasticizers, emulsifiers, softeners, penetrants, and foundation materials in lacquers, varnishes, and other protection coatings.

(8) Determine the economic and technical feasibility of utilizing cull and surplus white potatoes for the production of industrial alcohol.

(9) Develop methods for the economical collection of vines for subsequent utilization as sources of alkaloids and fiber or cellulose.

(10) Develop methods of processing the whole potato which will permit long-term bulk storage thereby making the raw material available in suitable conditions for industrial or other uses.

(11) Develop new or improved methods for the dehydration of potatoes with reference to: Preliminary chemical or other treatment to increase the permeability of the cell walls of the potato thereby facilitating the removal of most of the water by mechanical means; preparation for drying including grinding, pulping, slicing, or other processing operations; and development of commercial scale drying equipment found most suitable for the purposes desired.

(12) Equipment of an engineering character as regards design and materials of construction, but limited to such size as may be required to secure adequate and essential engineering and economic data, will be procured, installed and operated to demonstrate the technical soundness of methods of producing new or improved products from potatoes and of new or improved methods of processing potatoes which originate in the laboratory or in other agencies.

(13) Surveys will be made (in cooperation with existing agencies) to determine and evaluate the utility and adaptability of new or improved potato starch and other potato product utilization processes. Basic surveys will be used also to determine the size and geographical distribution of raw material supplies, small and large factory sites, transportation costs, prospective markets, the effect of new and competing products upon price levels in existing markets, the distribution and capacity of related processing industries to those factors which may affect the commercial success of the new developments.

Due to the great importance of the potato crop in the Eastern and Western producing areas, research on this commodity will be done

in the Eastern and Western Regional Laboratories. The above plan of work deals with research problems to be undertaken at both laboratories. Coordination of the studies in each laboratory has been carefully planned; investigations at the Eastern Laboratory will comprise all of the undertakings mentioned except pre-treatment and raw material storage problems which will be performed at the Western Laboratory.

Tanning Materials, Hides and Skins, and Leather Utilization Inves.
(Eastern Laboratory)

The Problem and its Significance: Hides, skins, and tanning materials are agricultural commodities that are essential raw materials for the leather industry. Leather is a national necessity in both peace times and war times. Domestic supplies of leather-making raw materials are inadequate, about one-half of them now being imported. For these reasons hides and tanning materials are classed, respectively, as strategic and critical items. National welfare demands the maintenance of a high degree of economic independence. This necessitates improvement in the quality of existing supplies of raw materials, elimination of their waste and spoilage, and their most efficient and complete conversion into finished products of maximum serviceability, supplemented by development of new supplies for replacement and augmentation.

In round numbers and normal times approximately 125 million hides and skins worth about 200 million dollars are tanned yearly in this country into leather valued at over 400 million dollars. This leather is converted into shoes, belting, harness, and other goods with a factory valuation of more than 1-1/4 billion dollars.

Hides and skins are among the highest price-per-pound raw materials that agriculture produces. Fresh hides and skins, like so much fresh meat, are perishable. They must be cured and preserved until ready to be tanned. During cure, storage, and transit hides and skins are subject to attack by bacteria, molds, yeasts, and insects, resulting in an annual spoilage and waste estimated at 20 million dollars. More ideal and more nearly foolproof methods of curing would eliminate most of this waste.

A promising virgin field of research having direct practical application is the measurement of the influence of breed, feed, sex, age, and environment of animals upon the properties of their hides and skins as reflected particularly by the quality of leather they make. Information thus acquired would show the direction in which steps could be taken to improve the inherent qualities of hides and skins and, hence, to increase their value to agriculture.

Elimination of spoilage and waste of hides and skins, improvement of their quality, maximum development of their most valuable inherent leather-making properties, and the possible establishment of new home sources are measures that would afford relief from inadequate domestic supplies and competitive foreign raw materials.

Tannin from agricultural products like barks, woods, leaves, roots, and fruits, is an essential constituent of sole, harness, belting, strap, upholstery, and other leathers. Established domestic supplies are insufficient, about one-half of the 15 to 20 million dollars worth used annually being imported from foreign sources. Furthermore, two-thirds of our domestic supply is now derived from the American chestnut tree, which is being exterminated by the chestnut blight. Aside from chestnut wood only about one-sixth of our total tannin requirements is of domestic origin. A constructive program demands the conservation of present supplies and development of new ones, preferably as new crops for agriculture to utilize acreage now producing surplus commodities and to promote soil-conserving land-use practices.

The admittedly incomplete knowledge of the proteins, together with the lack of information concerning the constitution of the natural tannins and nontannins make tanning an extremely involved process. Most tanning today is done with some degree of chemical control, but in many respects tanning is still as much an art as it is a science. Fundamental research on the chemistry of tanning has tremendous possibilities in developing more scientific, shorter, and better methods of making less costly and more serviceable leathers, and, consequently, in promoting a greater utilization and stronger demand for agricultural raw materials from which leather is made.

Agriculture not only supplies the raw materials but as a group is perhaps the largest consumer of the finished products derived therefrom. Agriculture may be said to have an annual investment in leather and leather goods of the order of 500 million dollars. The problems involved are national in both scope and importance. Furthermore, constructive work directed toward the goal set forth requires facilities for research in plant propagation, animal husbandry, crop production, land-use practices, and long-range scientific studies that are not available to and cannot be coordinated by private interests.

Preparedness for a national emergency demands serious attention to assure adequate supplies of hides, skins, and tanning materials for making leather. Research should be directed immediately toward existing domestic raw materials that might be developed quickly into important new sources of tannin. This should be supplemented by increased effort to bring into reality as soon as possible assured annual supplies through cultivation of tannin-bearing plants as crops. With the cutting off of foreign materials and the passing of the American chestnut tree our self-sufficiency in tannin supplies would be of the order of only 15 percent, unless domestic replacements were developed in the meantime. The United States imports about 12 percent of the cattle hides, 25 percent of the calfskins, 55 percent of the sheepskins, and over 99 percent of the goatskins used for making leather. Much of our domestic production of hides and skins suffers deterioration and spoilage from improper packing and curing. A substantial proportion of it comes from small butchers and dealers relatively unskilled and uninformed on the curing and handling of hides and skins. Domestic supplies could be greatly enhanced both in

quality and quantity through the introduction and establishment of improved practices in the preparation and better preservation of these raw materials until they reach the tannery.

Plan of Work: (1) A broad program of research will be continued to improve existing procedures and develop new and more effective ones for the preservation of hides and skins during cure, storage, and transportation.

(2) The influence of life factors upon the condition and value of hides and skins for making leather and furs will be determined to show steps to take for maximum development of their most valuable inherent properties and for establishing a more scientific system for classifying hides and skins according to their intrinsic value.

(3) Domestic and foreign tanniferous plants will be grown experimentally (in cooperation with existing agencies) and evaluated for their possibilities as tannin crops to replace dwindling home supplies of tanning materials as sources of valuable co-products, and means for prevention of soil erosion and diversification of land use. Agricultural wastes will be investigated as sources of tannin. The chemistry and constitution of the tannins will be ascertained if possible to point the way toward their more efficient application in tanning and to new uses and new products.

(4) The most effective utilization of leather-making raw materials will be sought through experimental tanning to develop shorter and more economical methods of tanning. The more complete recovery and profitable use of the wastes from tanning materials and processes will be undertaken.

(5) Experimental leathers tanned, treated, and finished in different ways will be examined for normal and abnormal properties and the data correlated with production history and service performance. Data on selection, use, and care of leather and leather articles will be secured from experimentally developed formulas and procedures and from the trade and consumers for the preparation and revision of specifications and for the information of Federal agencies and the public.

Alfalfa Utilization Investigations
(Western Laboratory)

The Problem and its Significance: Alfalfa leads all common hay crops in terms of tonnage and value, the annual production of alfalfa hay during the period 1919-1938 showing a net increase of from 20 to 29 million tons, while that of clover and timothy correspondingly declined from 43 to about 27 million tons. Approximately 14 million acres are now devoted to alfalfa production, the farm value of alfalfa for 1937 being 283 million dollars. The recognized superiority of alfalfa over other forage crops is due to a combination of factors--its average yield is nearly twice that of clover and timothy; it is a deep-rooted, and nodule-forming legume, protecting the soil and offering advantages for soil conservation; it decisively outranks all other important forage crops in total dry matter and in digestible nutrients per unit weight.

Alfalfa production is widely distributed throughout the United States, being best suited to soil and climatic conditions in the West, and in the semi-arid Great Plains region, the principal producing states being California, Minnesota, Wisconsin, Idaho, Montana, Colorado, and Nebraska.

Alfalfa surpluses usually are local and seasonal in character. Chief among the causes of such surpluses are: (1) Abnormally heavy local production; (2) local scarcity of farm animals; (3) prohibitive cost of transportation due to bulkiness of the material. Transportation difficulties are also complicated by drastic quarantine restrictions with reference to the alfalfa weevil. Due to this situation alfalfa prices undergo wide fluctuations. During the period 1932-1936, average yearly prices varied from $7.00 to $14.50 per ton of hay. The current surplus in Montana caused a price quotation of $4.25 per ton on August 15, 1939, while in October the price of first quality hay in some sections of Montana had dropped to $3.00 or less.

To alleviate this surplus problem through new outlets, a substantial part of the processing will need to be done locally because of bulkiness with attendant high transportation costs. The development of low-cost and efficient recovery methods in the processing, and isolation of alfalfa constituents such as protein, pigments, vitamins, hormones, cellulose, hemicellulose, lignin and lipids should provide means of utilizing it in ways other than as a hay crop.

Alfalfa is used as a pasture crop to only a negligible extent, and ensiling of alfalfa is not recommended. About 400,000 tons of alfalfa hay are annually converted into "cut or chopped" alfalfa, or into meal intended for use in the preparation of mixed feeds.

Up to the present time, alfalfa utilization and research has emphasized chiefly the agronomic and nutritional aspects. Comparatively little has been accomplished in the isolation or processing of individual alfalfa constituents for special purposes. Recently, however, widespread interest has been manifested in the use of alfalfa as a basic raw material for the preparation of valuable pigments, vitamins, and related substances.

Low cost raw materials are essential for successful industrial utilization for large volume usage. In this connection it is significant to note that alfalfa is one of the cheapest farm commodities produced. The production cost per pound of dry plant material ranges from 1/5 to 3/4 of a cent per pound. Alfalfa contains 15 to 20 percent protein, which is produced, in the plant material, at a cost of 1-1/2 to 2-1/2 cents per pound. If low cost, efficient protein recovery methods are developed, alfalfa should become an important commercial source of plant protein and thus extend its uses considerably beyond its present status.

In a national emergency every advantage should be taken of the superior feed values of alfalfa, as these relate both to animal and to

human nutritional requirements. Alfalfa carotene offers great potentialities as a domestic source of vitamin A concentrates for which we have long been accustomed to rely largely upon foreign importations of fish liver oils. The proteins of alfalfa present possibilities both for the preparation of high protein feed concentrates of superior nutritional quality, and for use in the production of plastic materials. Alfalfa also yields a high tonnage of cellulose having presumably the same potential values as the cellulose residues of other agricultural commodities.

Plan of Work: In the endeavor to discover and to develop new, extended and improved possibilities for alfalfa utilization, the following fields will be investigated:

(1) Effects of variable conditions of alfalfa production, of maturity, and of harvesting, dehydration, storage, grinding and processing methods on the quantity and character of each supposedly important alfalfa constituent.

(2) Use of intact alfalfa as a source of industrial structural commodities such as pressed board, cheap plastics, insulating material, etc.

(3) Methods for identification, characterization, quantitative estimation, concentration, and recovery of proteins, vitamins, pigments, enzymes, hormones, lipids, hemicellulose, cellulose, and lignin of alfalfa.

(4) Integration of procedures for the recovery and processing of different alfalfa constituents.

(5) Possible utilization of pigments, vitamins, enzymes, and hormones as pharmaceuticals, coloring agents, food and feed preparations, and as basic materials for organic synthesis.

(6) Potentialities of alfalfa protein for the production of food and feed concentrates, and of industrially important materials and as plastics, adhesives, fibers, etc.

(7) Possibilities for industrially useful structural materials from cellulose, hemicellulose, and lignin residues resulting from processing operations used for the removal of pigments, vitamins, proteins, lipids, etc.

(8) Development of operations to pilot plant scale if and when justification is found.

(9) Economic factors, including cost analyses, availability, low grade or damaged material, local processing possibilities, marketing and transportation features, consumer requirements and competitive factors (in cooperation with existing agencies).

Fruits Utilization Investigations
(Western Laboratory)

The Problem and its Significance: Fruit growing is a widely distributed and highly diversified farm activity in the United States with a total gross farm value, averaged for 1936 and 1937, of $506,565,000 of which about 50 percent ($253,636,000) was produced in the Western area. Increasingly large tonnages of surpluses are being encountered in the

fruit industry and frequently a particular crop may attain such a large yield that not only are prices depressed below production costs but huge quantities of the crop are completely wasted. Present world conditions do not indicate any improvement in this situation, by way of increased exports, in the near future.

Substantial portions of fruit crops are unmarketable as fresh fruit because of grading requirements, surpluses above market capacity, freezing, or damage by orchard pests. Annual loss due to these factors varies with the season but may attain as much as 30-50 percent of the total crop. These culls and lower grade fruit constitute a serious marketing problem and act as an entering wedge in lowering the price obtained for first grade fruit. New byproduct outlets would help to stabilize the fruit industry against the effects of discrepancies between production and market demand.

In addition to culls and surpluses large quantities of wastes from canning and juice plants accumulate annually. It is estimated that not less than 175,000 tons of peel, seeds, and rag from citrus fruit canning and juice plants are discarded annually. Examples of other wastes are: peach pits, 30,000 tons; grape pomace, 185,000 tons; pears, 120,000 tons. The profitable utilization of such waste materials, for example as a source of vitamins, pectin, oils, citric, tartaric and other acids, pigments, waxes and other products, or for composts, would increase the income of the producer and at the same time solve serious disposal problems.

Further development of the frozen-pack industry gives promise of very marked and favorable influences on the welfare of the fruit growing industry as well as on the national food economy. Due to the high degree of fresh quality retained by products preserved by freezing, this method not only provides essentially fresh foods of a ready-to-use character and without waste but embodies the principles of better distribution of perishables with diminished wastage and links with modern concepts of food transport, merchandising and use.

The production of fruits, and with few exceptions their processing, is not confined to a few organizations or individuals with large financial resources. This means that the industry is widely scattered and not in a position to carry on research toward utilization of the crop. The problem of surplus disposal of fruits is therefore sectional in scope.

New products, especially of a non-food character, should be developed to provide a means of diverting surpluses and utilizing culls and wastes. Such a program of extended uses for fruit products must be geared to the economic conditions existing in the industry for smooth and effective operation. It must be broad and diversified to handle efficiently and economically the large quantities of material available.

The inevitable shortage of tin if Pacific trade-routes should be closed to the United States would produce so serious a dislocation of

normal outlets for many of the fruits which have become an indispensable part of the American diet that immediate steps should be taken to develop supplementary methods of fruit preservation. Efforts should be made to extend freezing preservation successfully to fruits other than berries. Fruits and fruit byproducts and wastes also offer possible sources of raw materials important to national security; fruit pits and nut shells may be used to produce the activated carbon essential to several industries and to gas mask production; and fruit-rind pectin may find a greatly increased usage in military medicine.

Plan of Work: The above objective will be sought through the following:

(1) Development of Industrial Products: The nature of the several constituents of fruits will be investigated in detail in order to learn which ones are of value in scientific, chemical, or technical fields and whether any of the natural constituents can be modified so as to be usable in this manner.

(2) Utilization of Processing Wastes: In a similar way intensive investigations will be carried on in order to develop industrial utilization of the fruit wastes which accumulate at packing houses and processing plants.

In all of the above activities the work will be devoted primarily to those constituents known or believed to have industrial or therapeutic use, such as vitamins, enzymes, amino and other organic acids, pectin and inorganic compounds. In addition, it is planned to devise new industrial uses for such constituents.

(3) Frozen Pack Technology: Investigations will be conducted on the chemical, physical, physiological and cytological behavior of fruit tissues and of enzymes and microorganisms affecting fruit tissues at low temperatures; on chemical, physical, biological, and engineering phases of handling and pretreatment and preparation of fruit in relation to freezing technique, storage, packaging, transport, and utilization to insure thereby the maintenance of product quality on a high level; and on commodity utilization, in the economic sense, to ascertain consumer and market preferences, costs of production and distribution, and problems of merchandising.

(4) Pilot Plant Development: The plan consists of: demonstration of the technical practicability of new processes for the utilization of fruits or fruit culls and wastes; development of designs and specifications of new processing equipment, and cost estimates or operation; to support other phases of research on new methods of utilization of fruits by the preparation of adequate samples of materials of specified characteristics; to prepare samples of materials for demonstration or other purposes where considerable quantities are required; to acquire such engineering data as may be necessary in connection with the foregoing.

(5) Industrial and Agricultural Surveys: In cooperation with existing agencies, surveys will be made of the areas of production and

the quantity, quality, and conditions of the varieties of fruits available for industrial utilization and the location and size of significant sources of fruit culls and processing wastes, due consideration being given to existing information, evaluation of the effect of trends in production and in farming and processing practices on potential future industrial utilization of fruits. Collection and interpretation of processing, distributing, and marketing information, and data on consumer requirements with respect to new products derived from fruits, all in relation to competing products and raw materials, will be given due consideration.

Poultry Utilization Investigations
(Western Laboratory)

The Problem and its Significance: Poultry is produced on approximately 86 percent of the total number of farms in the United States and is second only to the meat and dairy industries in dollar value of production. This, together with the fact that a larger number of agricultural people are associated with poultry raising than with any other single farm activity indicates the importance of the poultry industry. Chickens provide by far the largest part of the poultry meat and eggs consumed and it is in this part of the industry that the significant surpluses, byproducts and wastes are found.

Poultry producers, packers, processors, and hatchery operators are not, as a rule, in a position to conduct research designed to extend the use of poultry products and byproducts since their activities are not confined to a few firms nor are they concentrated at a few centers. Consequently, there is a very definite need for a coordinated program of government research designed to develop new or improved processing technique and food preparation and new products from wastes. This should result in increased returns to the producer as well as improved and more economical products to the consumer. Poultry research in the past has dealt largely with breeding, disease control, nutrition problems and to a lesser extent with processing, packaging and preservation of poultry and but little fundamental research on poultry wastes and eggs.

The poultry processing industry which is making rapid strides in becoming established for the preparation of frozen, ready-to-cook products is in need of (a) efficient and economical methods and equipment for use in the extension of freezing-preservation to attain low unit costs of operation and the retention of the characteristics of freshly dressed poultry, and (b) economic utilization of the non-food or wastes which accumulate as a direct result of the dressing eviscerating processes. The development of uses for poultry offal would encourage the general adoption by the poultry industry of the practice of eviscerating poultry at central packing plants located in producing areas thereby effecting a large saving in transportation costs in addition to the value realized from new products obtained from the offal. The total amount of processed poultry produced in 42 packing plants and certified during the fiscal year ending June 30, 1939, was 47,077,374 pounds.

The hatchery industry would be greatly benefited by the development of (a) useful materials from the millions of annually accumulated rejects or partially incubated eggs, and (b) methods for the recovery of active biological principles such as hormones, bios factors, and other fractions from discarded chick embryos and day-old cockerels, which accumulate as a result of the "sexing" of chicks. During 1937-38 there were an estimated 60,666,000 pounds of eggs of a total of approximately 191,000,000 pounds set which failed to hatch because of infertility and which were largely discarded as waste.

The egg and egg-products industries are in need of the development of (a) non-food products from the annual surplus of more than four million pounds of egg whites, and (b) the production of a standardized "tanners" egg from the inedible rots, chex and leakers which accumulate at egg-grading and packing plants.

The poultry industry may serve national security in an emergency through the use of byproducts now mostly wasted. Offal from packing plants may be used as a source of specific biological and pharmaceutical preparations for which there may be increased need. Fowl tendons may be developed as surgical sutures. The use of keratin proteins, such as feathers, for the production of synthetic fibers to supplement wool, and for development of high-strength plastic materials, should be investigated. The distribution of poultry itself may be improved to conserve shipping space by the wider development of freezing-preservation of fowl dressed at production centers.

Plan of Work: The following lines of investigation will be undertaken:

(1) Development and improvement of freezing preservation methods as applied to poultry products and byproducts.
(2) Study of fundamental properties and utilization of egg white and feather proteins.
(3) Improvement of quality and standardization of tanners egg preparations for use on finished leathers.
(4) Investigation of the composition, identification and preparation of concentrates of poultry product constituents including hormones, bios and other biologics.
(5) Pilot plant development of new or improved processes.
(6) Industrial and agricultural surveys (in cooperation with existing agencies).

PASSENGER-CARRYING VEHICLES

The estimates further provide $1,300 for the replacement of one passenger-carrying vehicle and the purchase of one additional car (both to be of the "station wagon" type) for use by members of the scientific staff of the Western Regional Research Laboratory, Albany, California, for travel and for transportation of heavy equipment throughout the Western farm producing area in order to carry on studies and experimental work at the various points of production.

Automobile transportation is practically indispensable for the proper conduct of the work at the Four Regional Research Laboratories since the area served by each laboratory ranges from nine to sixteen states, where in many instances experimental work must be conducted at points situated in remote areas where public transportation facilities are very limited and in many cases not at all available.

The car to be replaced in 1942 is a 1932 model with a total mileage as of June 30, 1940 of approximately 48,000 miles. (This car was originally located at the Frozen Pack Laboratory, Seattle, Washington, the work of which has been transferred to the Western Laboratory). Inasmuch as considerably more mileage will be added to this car before it is actually turned in, it appears to be distinctly in the best interests of the work to replace it during the fiscal year 1942, as herein provided.

BOUND BY